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Sir:

Transmitted herewith for filing under 37 CFR 1.53(b) is the

- ☒ patent application of  
☐ continuation patent application of  
☐ divisional patent application of  
☐ continuation-in-part patent application of

Inventor(s)/Applicant Identifier: **Kunihiko Miyazaki, Ryoichi Sakai, Kazuo Takaragi, Seiichi Susaki, Toshiyuki Moritsu, Mizuhiro Sakai, Mitsuru Iwamura, and Tsutomu Matsumoto**

For: **Digital Signing Method**

- ☒ This application claims priority from each of the following Application Nos./filing dates:  
Japanese Patent Application No. P11-301216, Filed October 22, 1999  
the disclosure(s) of which is (are) incorporated by reference.
- ☐ Please amend this application by adding the following before the first sentence: "This application is a ☐ continuation ☐ continuation-in-part of and claims the benefit of U.S. Application No. 60/\_\_\_\_\_, filed \_\_\_\_\_, the disclosure of which is incorporated by reference."

Enclosed are:

- ☒ 33 page(s) of specification  
☒ 8 page(s) of claims  
☒ 1 page of Abstract  
☒ 12 sheet(s) of ☐ formal ☒ informal drawing(s).  
☒ An assignment of the invention to Hitachi, Ltd.  
☒ A ☒ signed ☐ unsigned Declaration & Power of Attorney  
☐ A ☐ signed ☐ unsigned Declaration.  
☐ A Power of Attorney by Assignee with Certificate Under 37 CFR Section 3.73(b).  
☐ A verified statement to establish small entity status under 37 CFR 1.9 and 37 CFR 1.27 ☐ is enclosed ☐ was filed in the prior application and small entity status is still proper and desired.  
☒ A certified copy of a Japanese application.  
☒ Information Disclosure Statement under 37 CFR 1.97, Form PTO-1449, and three references.  
☐ A petition to extend time to respond in the parent application.  
☐ Notification of change of ☐ power of attorney ☐ correspondence address filed in prior application.  
☒ Recordation Form Cover Sheet.

	(Col. 1)	(Col. 2)	
FOR:	NO. FILED	NO. EXTRA	
BASIC FEE			
TOTAL CLAIMS	33 - 20	= *13	
INDEP. CLAIMS	8 - 3	= *5	
<input type="checkbox"/> MULTIPLE DEPENDENT CLAIM PRESENTED			

\* If the difference in Col. 1 is less than 0, enter "0" in Col. 2.

## SMALL ENTITY

RATE	FEE
	\$345.00
x \$9.00 =	
x \$39.00 =	
+ \$130.00 =	
TOTAL	

OR

## OTHER THAN SMALL ENTITY

RATE	FEE
	\$710.00
x \$18.00 =	\$234.00
x \$80.00 =	\$400.00
+ \$260.00 =	
TOTAL	\$1,344.00

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Respectfully submitted,  
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# PATENT APPLICATION

## DIGITAL SIGNING METHOD

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## **DIGITAL SIGNING METHOD**

### **BACKGROUND OF THE INVENTION**

This application claims priority from Japanese Patent Application  
Reference No. P11-301216, filed October 22, 1999.

Further, this application claims priority from Japanese Patent Application  
10 Reference No. P2000-081712, filed March 17, 2000.

### **BACKGROUND OF THE INVENTION**

The present invention relates generally to digital signature techniques, and  
specifically to techniques for authenticating a digitally signed document.

15

Digital signature techniques add the function of the conventional seal to a  
digitized message such as an electronic document, and are attracting attention since the  
techniques make it possible to develop advanced applications of networks as seen in  
electronic commerce.

20

In conventional digital signature techniques, a digital signature generator  
applies a secret key that it secretly holds to a message M to be signed or to its hash value,  
which is a characteristic value as well as a message digest, to generate a digital signature  
A for the message M. Then, the message M is made public with the digital signature A  
attached to it. A digital signature verifier applies a public key paired with the above  
secret key to the digital signature A attached to the message M, and compares the result  
25 against the message M or its hash value. If they do not coincide, the message M may  
have been altered one way or another after the digital signature A was generated. Only  
when they coincide, therefore, can the verifier authenticate that the digital signature A  
was generated for the present message M.

30

However, such conventional digital signature techniques are often based  
upon an assumption that each digital signature generator maintains its own secret key in  
complete security. That is, it is assumed that the only person who can generate a digital  
signature which can be verified by use of a specific public key is a digital signature  
generator who lawfully holds a secret key paired with the public key.

What is really needed are techniques for determining whether a digital signature was generated by a digital signature generator, or if the digital signature was generated by a third party posing as the digital signature generator.

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## SUMMARY OF THE INVENTION

According to the invention, techniques for authenticating that a digitally signed document is genuine are provided. Specific embodiments according to the present invention can determine whether a digital signature was generated by a digital signature generator, or if the digital signature was generated by a third party posing as the digital signature generator. Specific embodiments can provide independent verification based upon prior signed messages, time/date stamps, and the like. Techniques according to the present invention can be embodied in methods, apparatus, computer software and systems.

Accordingly, in a first aspect of the present invention, on the digital signature generator side, log data of a digital-signature-attached message is registered with a log list before the digital-signature-attached message is distributed. The digital-signature-attached message includes a generated digital signature and a message. Here, the log data may be the digital-signature-attached message itself, or it may be another digital-signature-attached message created by replacing the message included in the original digital-signature-attached message with its hash value.

As used herein, the term “hash value” refers to a value computed using a function called a “hash function”, which produces a fixed-length value from a variable-length input value. To ensure security, it is desirable to employ such a function with which it is difficult to find two input values that correspond to the same output value as well as to find an input value that corresponds to a given output value. In specific embodiments, the algorithm of a hash function to be used is publicly available across the entire system.

This makes it possible for a digital signature verifier to verify whether a digital-signature-attached message to be verified is distributed by a digital signature generator, by obtaining a log list from the digital signature generator and checking whether log data of the digital-signature-attached message to be verified is registered with the log list.

Further, according to a second aspect of the present invention, a digital signature generator sends a digital signature for a message that the generator itself generated, to a time stamping authority, which is a reliable third party, and asks the station to generate a signature of the time stamping authority, the signature is called the timestamp, and in a specific embodiment, can be made using the digital signature and time data with a secret key that the time stamping authority secretly holds. The digital signature generator, then, distributes the above message with this timestamp attached thereto.

Accordingly, a digital signature verifier can derive the time data and the digital signature from the timestamp attached to the message by use of a public key paired with the secret key held by the time stamping authority, and verify whether the validity of the digital signature is assured by its digital signature generator by checking whether date and time indicated by this time data exceeds the date and time given by the digital signature generator beforehand.

As used here, the term "IC card" refers to a card formed of a flexible material, for example, body that comprises a chip, or module, embedded within it. IC cards are also referred to as "smart card," "chip card" or "memory card," for various types.

Numerous benefits are achieved by way of the present invention over conventional techniques. Specific embodiments according to the present invention can determine whether a digital signature was generated by a digital signature generator, or if the digital signature was generated by a third party posing as the digital signature generator. Further, some specific embodiments can provide independent verification of digital signer identity based upon prior signed messages, time/date stamps, and the like.

These and other benefits are described throughout the present specification. A further understanding of the nature and advantages of the invention herein may be realized by reference to the remaining portions of the specification and the attached drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates a schematic diagram of a representative example system in a first embodiment of the present invention.

Fig. 2 illustrates a schematic diagram of a representative embodiment of a digital signer side apparatus 1, a purchaser side apparatus 3, a digital signature verifier side apparatus 5, a mediator side apparatus 7, and a timestamp issuing apparatus 8 shown in Fig. 1.

5 Fig. 3 illustrates a schematic diagram of a representative example embodiment of an IC card 22 shown in Fig. 2.

Fig. 4 illustrates a flowchart of representative example processes in which a purchaser side apparatus 3 acquires a digital-signature-attached message from a digital signer side apparatus 1 in the first embodiment of the present invention.

10 Fig. 5 illustrates a flowchart of representative example processes in which a purchaser side apparatus 3 asks a digital signature verifier side apparatus 5 to verify a digital-signature-attached message acquired from a digital signer side apparatus 1 in the first embodiment of the present invention.

15 Fig. 6 illustrates a flowchart of representative example processes in which a digital signer side apparatus 1 asks a digital signature verifier side apparatus 5 to verify a digital-signature-attached message that the digital signer side apparatus 1 itself has generated in the first embodiment of the present invention.

Fig. 7 illustrates a diagram of representative example of data stored in a signature log table 2234 in the second embodiment of the present invention.

20 Fig. 8 illustrates a flowchart of representative example processes in which a purchaser side apparatus 3 asks a digital signature verifier side apparatus 5 to verify a digital-signature-attached message acquired from a digital signer side apparatus 1 in the second embodiment of the present invention.

25 Fig. 9 illustrates a flowchart of representative example processes in which a digital signer side apparatus 1 asks a digital signature verifier side apparatus 5 to verify a digital-signature-attached message that the digital signer side apparatus 1 itself has generated in the second embodiment of the present invention.

30 Fig. 10 illustrates a flowchart of representative example processes in which a purchaser side apparatus 3 acquires a digital-signature-attached message from a digital signer side apparatus 1 in the third embodiment of the present invention.

Fig. 11 illustrates a flowchart representative example processes in which a purchaser side apparatus 3 asks a digital signature verifier side apparatus 5 to verify a

digital-signature-attached message acquired from a digital signer side apparatus 1 in the third embodiment of the present invention.

Fig. 12 illustrates a diagram of a representative data stored in a signature log table 2234 in a modification of the third embodiment of the present invention.

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## DESCRIPTION OF THE SPECIFIC EMBODIMENTS

The present invention provides techniques for authenticating that a digitally signed document is genuine. Specific embodiments according to the present invention can determine whether a digital signature was generated by a digital signature generator, or if the digital signature was generated by a third party posing as the digital signature generator. Further, independent verification of digital signer identity based upon prior signed messages, time/date stamps, and the like, can be performed. Techniques according to the present invention can be embodied in methods, apparatus, computer software and systems.

Conventional digital signature techniques are described, for example, in the following references, Alfred J. Menezes, Paul C. van Oorshot, and Scott A. Vanstone, "Handbook of Applied Cryptography", CRC Press, Inc. 1997, Bruce Schneier, "Applied Cryptography Second Edition", John Wiley & Sons, Inc. 1996, International Application Number PCT/US91/05386, and "Standard Specifications for Public Key Cryptography (Draft Version 11)", IEEE P1363, IEEE, July 1999, the entire contents of which is incorporated herein by reference for all purposes. While important contributions to the field in their own right, opportunities for further improvement in security not heretofore known in the art can be achieved by specific embodiments according to the present invention.

Conventional digital signature techniques are often based upon an assumption that each digital signature generator secretly holds its own secret key. That is, it is assumed that the only person who can generate a digital signature which can be verified by use of a specific public key is a digital signature generator who holds a secret key paired with the public key. If a third party illegally obtains a secret key of a digital signature generator due to an error in key management on the digital signature generator side or some other reason, and generates a digital signature posing as the digital signature generator, such an illegality can not be detected by the above digital signature technique.

One technique applies a second secret key held by a digital signature generator to both a message and the digital signature for the message to newly generate a digital signature for the message. However, this technique is intended to ensure the security of the previous digital signatures generated by a digital signature generator when it has become highly possible for a third party to obtain a secret key of the digital signature generator as a result of the recent rapid increase in the computational capability of computers or improved algorithm for deriving the secret key from a public key. For a more detailed description of such techniques, further reference may be had to an International Application Number PCT/US93/1117.

One illegality prevention technique is designed to prevent a digital signature generator from generating a new digital signature by somehow altering a message that the generator generated before, and replacing the original message and the original digital signature with the new ones. Specifically, a digital signature generator applies a secret key that the generator secretly holds, to a message  $M_n$  to be signed or its hash value, the hash value of the message used immediately before, and time data to generate a digital signature  $A_n$  for the message  $M_n$ . This assures that a digital signature  $A_{n+1}$  generated immediately after the digital signature  $A_n$  reflects the message  $M_n$ . With this arrangement, if a digital signature generator adds an alteration to the message  $M_n$  that the generator has generated so as to generate a new digital signature, and replaces the original message  $M_n$  and the original digital signature  $A_n$  with the new ones, such an illegal conduct will cause the new message and signature to fail to match the digital signature  $A_{n+1}$ . For a more detailed description of such techniques, further reference may be had to a publication by Bruce Schneier entitled, "Applied Cryptography Second Edition", John Wiley & Sons, Inc. 1996, and an International Application Number PCT/US91/05386, for example.

Fig. 1 is a schematic diagram of a representative example system in a first embodiment according to the present invention.

As shown in the figure, this system comprises digital signer side apparatuses  $1_1$  through  $1_n$  (hereinafter referred to as digital signer side apparatuses 1) for creating digital-signature-attached messages, purchaser side apparatuses  $3_1$  through  $3_n$  (hereinafter referred to as purchaser side apparatuses 3) for holding digital-signature-attached messages created by the digital signer side apparatuses 1, a digital signature verifier side apparatus 5 for verifying digital-signature-attached messages created by the



digital signer side apparatuses 1, and a mediator side apparatus 7 for publishing lists of messages created by the digital signer side apparatuses 1, and acquiring digital-signature-attached messages from the digital signer side apparatuses 1 on behalf of the purchaser side apparatuses 3.

5                   It should be noted that in descriptions of the embodiments of the present invention, the term “message” includes, in addition to digital data such as electronic documents, digitized multimedia data such as image data and audio data, and digital data having the same value as that of securities. Furthermore, when used in descriptions of the embodiments of the present invention, the term “purchase” refers to an action to acquire,  
10                   one way or another, a digital-signature-attached message created by a digital signer, whether on free of charge or on a charge basis.

                  Fig. 2 is a schematic diagram of a representative example embodiment of the digital signer side apparatuses 1, the purchaser side apparatuses 3, the digital signature verifier side apparatus 5, the mediator side apparatus 7, and the timestamp issuing  
15                   apparatus 8.

                  Each apparatus can be constructed by connecting an IC card 22 which is a storage medium having a computational function, to a computer 21 which has a general configuration comprising a CPU 11, a RAM 12 functioning as a work area for the CPU 11, an external storage device 13 such as a hard disk device, a reading device 14 for  
20                   reading data from a portable storage medium 15 such as a CD-ROM and an FD, an input device 16 such as a keyboard or a mouse, a display device 17 such as a monitor, a communication device 18 for communicating with other apparatuses through a network, an IC card connecting device 19, and an interface 20 used for transmitting and receiving data between the above apparatuses.

25                   The external storage device 13 in each digital signer side apparatus 1 stores a signature-attached message creating program 131 for causing the IC card 22 to generate a digital signature for a message and attaching the generated digital signature to the message before distributing the message as a digital-signature-attached message, and a verification requesting program 132 for causing the digital signature verifier side  
30                   apparatus 5 to verify a digital-signature-attached message created by the digital signer side apparatus 1 and providing the digital signature verifier side apparatus 5 with information necessary for the digital signature verifier side apparatus 5 to verify the digital-signature-attached message, according to the instructions of the digital signature

verifier side apparatus 5. These programs are loaded into the RAM 12 so that the CPU 11 executes them as processes such as a signature-attached message creation processing section 111 and a verification request processing section 112.

The external storage device 13 in each purchaser side apparatus 3 stores a signature-attached message acquiring program 331 for acquiring a digital-signature-attached message from a digital signer side apparatus 1, and a verification requesting program 332 for causing the digital signature verifier side apparatus 5 to verify the acquired digital-signature-attached message. These programs are loaded into the RAM 12 so that the CPU 11 executes them as processes such as a signature-attached message acquisition processing section 311 and a verification request processing section 312.

The external storage device 13 in the digital signature verifier side apparatus 5 stores a signature verifying program 531 for verifying a digital-signature-attached message according to the instructions of a digital signer side apparatus 1 or a purchaser side apparatus. This program is loaded into the RAM 12 so that the CPU 11 executes it as a process called a signature verification processing section 511.

The mediator side apparatus 7 acquires a digital-signature-attached message from a digital signer side apparatus 1 on behalf of a purchaser side apparatus 3. Basically, the mediator side apparatus 7 has the same configuration as that shown in Fig. 2. The IC card connecting device can be omitted from each of the purchaser side apparatuses 3, the digital signature verifier side apparatus 5, and the mediator side apparatus 7.

The above-described programs may be read from the portable storage medium 15 such as a CD-ROM or an FD by the reading device 14 and installed in the external storage device 13, or they may be downloaded from the network into the external storage device 13 through the communication device 18. The programs may be embodied in a carrier wave, which is a computer readable medium for transmitting a computer program.

Fig. 3 is a schematic diagram of a representative example embodiment of the IC card 22 shown in Fig. 2.

As shown in the figure, the IC card 22 comprises a CPU 221, a RAM 222 functioning as a work area for the CPU 221, an EEPROM 223 for storing various programs and data, and an I/O 224 for communicating with the computer 21 through the IC card connecting device 19. When used in descriptions of this invention, the term

“EEPROM” refers to a read-only memory whose stored data can be electronically rewritten.

The EEPROM 223 stores a signature generating program 2231 for generating a digital signature for a message according to the instructions of the signature-attached message creation processing section 111, a secret key 2232 used for generating a digital signature, a public key certificate 2233 containing a public key paired with the secret key 2232, and a signature log table 2234 for recording the history of generation of digital signatures. The signature generating program 2231 and the secret key 2232 are set when the IC card 22 is issued. They are set so that they cannot be read from outside the IC card 22. Data and programs, such as the signature generating program 2231, which are not rewritten once they have been written at the time of issuing the IC card 22, may be stored in a non-rewritable ROM instead of the EEPROM 223. The public key certificate 2233 is set when the IC card 22 is issued. It is set so that it can be read from outside the IC card 22. The signature log table 2234, on the other hand, is set so that no data is recorded in the table at the time of issuing the IC card 22, and each time the IC card 22 generates a digital signature, the table adds a signature log 2235 comprised of the generated digital signature, a hash value of a message to be signed, and the name of the purchaser (the address of a purchaser side apparatus 3 or the like) of the message to be signed. It is assumed that the signature log table 2234 is set so that its data can be read from outside the IC card 22, but cannot be rewritten or deleted from outside IC card 22. The example in Fig. 3 shows the state of the IC card 22 after the digital signature generating operation has been performed N times on the IC card 22, indicating N signature logs 2235 recorded in the signature log table 2234.

The IC card issuer may perform the issuing operation of the IC card 22, that is, an operation in which the signature generating program 2231, the secret key 2232, and the public key certificate 2233 are stored and set in the EEPROM 223. Or the IC card issuer may issue the IC card 22 in a state that the EEPROM 223 stores only the signature generating program 2231, and a digital signer that owns the IC card 22 may store and set the secret key 2232 and the public key certificate 2233 in the EEPROM 223.

When the digital signer stores and sets the secret key 2232 in the EEPROM 223, it is desirable for the digital signer to execute a secret-key generating program that is stored in the IC card 22 by the IC card issuer beforehand so that the digital signer itself does not know the value of the secret key 2232.

The CPU 221 creates a signature generation processing section 2211 as a process by loading and executing the signature generating program 2231 in the RAM 222.

Next, referring to Fig. 4, description will be made of representative example processes in specific embodiments in which a purchaser side apparatus 3  
5 acquires a digital-signature-attached message from a digital signer side apparatus 1.

In a digital signer side apparatus 1, when the signature-attached message creation processing section 111 receives a request for transmission of a message from a purchaser side apparatus 3, the section reads the requested message from, for example, the external storage device 13 in which various messages are stored, and applies a hash  
10 function to the message to acquire its hash value. Then, the section asks the signature generation processing section 2211 to generate a signature by sending to it the hash value of the message and the address of the purchaser side apparatus 3 that has sent the transmission request (S6101). The signature generation processing section 2211 applies the secret key 2232 to the sent hash value of the message to generate a digital signature  
15 for the message (S6102). The signature generation processing section 2211 registers a signature log 2235 which is comprised of the hash value of the message, the digital signature, and the address of the purchaser side apparatus 3 that requested the transmission, with the signature log table 2234 (S6103), and sends the digital signature and the public key certificate 2233 to the signature-attached message creation processing  
20 section 111. The signature log table 2234 is preferably indexed beforehand so as to sequentially manage data in order to clarify the chronological relationships between the signature logs. The signature-attached message creation processing section 111 creates a digital-signature-attached message by attaching the above digital signature to the message whose transmission has been requested, and sends the digital-signature-attached message  
25 with the public key certificate 2233 attached thereto, to the purchaser side apparatus 3 that has requested the transmission (S6104).

In a purchaser side apparatus 3, when the purchaser has requested acquisition of a message through an input device 36, the signature-attached message acquisition processing section 311 sends a request for transmission of the message to a  
30 digital signer side apparatus 1 that holds the message (S6001), and waits for a digital-signature-attached message to be transmitted from the digital signer side apparatus 1 (S6002). The signature-attached message acquisition processing section 311 verifies the digital signature included in the received digital-signature-attached message.

Specifically, the section obtains two hash values: one found by processing the digital signature with the public key of the public key certificate 2233 attached to the digital-signature-attached message, and the other computed from the message included in the digital-signature-attached message. Then, the two hash values are compared (S6003). If they coincide (the result is OK at step S6004), the signature-attached message acquisition processing section 311 authenticates that the digital signature has been generated for the message included in the digital-signature-attached message, and accepts the digital-signature-attached message and stores it in an external storage device 33 or the like after attaching the address of the digital signer side apparatus 1 from which the message was obtained, to the message(S6005). If they do not coincide (the result is NG at step S6004), the signature-attached message acquisition processing section 311 does not authenticate the digital-signature-attached message and discards it (S6006).

Before actually accepting a digital-signature-attached message, the purchaser side apparatus may ask the digital signature verifier side apparatus 5 to verify the signature as necessary to check the validity of the signature as described later, depending on, for example, the importance of the digital-signature-attached message.

When the mediator side apparatus 7 acts as a purchaser side apparatus 3, the mediator side apparatus 7 performs the flow of steps for the purchaser side apparatus 3 as shown in Fig. 4, and sends a signature-attached message accepted at step S6005 to the purchaser side apparatus 3. This can reduce the burden on the purchaser side apparatus 3 since the purchaser side apparatus 3 does not need to perform the verifying process indicated at step S6003. It should be noted that the mediator side apparatus 7 preferably acquires information about the messages owned by each digital signer side apparatus 1 beforehand, and makes available to each purchaser side apparatus 3 a list of the messages owned by each digital signer side apparatus 1 by use of the World Wide Web or other means.

Each digital signer side apparatus 1 can create a digital-signature-attached message at the request of a digital signer, whether or not a purchaser side apparatus 3 asks it. In this case, the flow of steps for the purchaser side apparatus 3 as shown in Fig. 4 is not performed. However, using the purchaser side apparatus 3, a purchaser of a digital-signature-attached message can verify the signature by causing the digital signature verifier side apparatus 5 to verify the signature as described later.

The steps taken in the above case will be described using as an example digital data whose message has the same value as that of securities (hereinafter such digital data is called an electronic bill). A digital signer who is also an issuer of an electronic bill creates and issues a signature-attached electronic bill by performing the flow of steps for the digital signer side apparatuses 1 as shown in Fig. 4 by use of a digital signer side apparatus 1. It should be noted that since the purchaser of the created signature-attached electronic bill cannot be specified at the time of issuing the electronic bill, the signature log 2235 registered with the signature log table 2234 does not include the address of the purchaser.

The mediator side apparatus 7 acquires signature-attached electronic bills issued by the digital signer side apparatuses 1, and makes them public using the World Wide Web or other means beforehand. Then, the mediator side apparatus 7 transmits a desired signature-attached electronic bill or sends it by postal mail at the request of a purchaser side apparatus 3. A person who wants to purchase an electronic bill can ask the digital signature verifier side apparatus 5 to verify the desired electronic bill beforehand by use of a purchaser side apparatus 3, and take the actual purchase procedure only when the validity of the electronic bill has been confirmed.

Next, referring to Fig. 5, description will be made of representative example processes in specific embodiments in which a purchaser side apparatus 3 asks the digital signature verifier side apparatus 5 to verify a digital-signature-attached message acquired from a digital signer side apparatus 1.

In a purchaser side apparatus 3, when a purchaser has requested verification of a digital-signature-attached message owned by the purchaser side apparatus 3 itself through the input device 36, the verification request processing section 312 asks the digital signature verifier side apparatus 5 to verify the digital-signature-attached message by sending the digital-signature-attached message to the digital signature verifier side apparatus 5 after attaching the address of the digital signer side apparatus 1 from which the message was acquired, to the message (S7001). Then, the verification request processing section 312 waits for the verification results to be transmitted from the digital signature verifier side apparatus 5 (S7002), and displays the verification results using, for example, a display device 37 (S7003).

In the digital signature verifier side apparatus 5, when the signature verification processing section 511 has received a request for verification of a digital-

signature-attached message from a purchaser side apparatus 3, the section performs the first-stage verification of the digital-signature-attached message sent with the request, as at steps S6003 and S6004 (S7101, S7102).

5 If the result is OK at step S7102, the signature verification processing section 511 authenticates the digital-signature-attached message and proceeds to step S7103. If the result is NG at step S7102, the section does not authenticate the message and sends the verification results to the purchaser side apparatus 3 that transmitted the verification request, and to the digital signer side apparatus 1 specified by the address attached to the digital-signature-attached message (S7108).

10 At step S7103, the signature verification processing section 511 asks the digital signer side apparatus 1 specified by the address attached to the digital-signature-attached message, to transmit all signature logs 2235 (called a signature log list) recorded in the signature log table 2234 (S7103), and waits for the signature log list to be transmitted from the digital signer side apparatus 1 (S7104), and then performs the  
15 second-stage verification of the digital-signature-attached message. Specifically, the signature verification processing section 511 checks whether the acquired signature log list includes a signature log that includes the digital signature included in the digital-signature-attached message and a message hash value computed at step S7101 (S7105).

If the acquired signature log list includes the signature log (if the result is  
20 OK at step S7106), the signature verification processing section 511 authenticates that the digital-signature-attached message has been validly generated by the digital signer side apparatus 1 that provided the signature log list, and sends the results to the purchaser side apparatus 3 that transmitted the verification request, and to the digital signer side apparatus 1 specified by the address attached to the digital-signature-attached message  
25 (S7107).

If the acquired signature log list does not include the signature log (if the result is NG at step S7106), this means that the digital-signature-attached message was not generated by the digital signer side apparatus 1 that provided the signature log list. Accordingly, the signature verification processing section 511 determines that a third  
30 party obtained the secret key 2232 one way or another and illegally generated the message posing as the digital signer, and sends the results to the purchaser side apparatus 3 that transmitted the verification request and to the digital signer side apparatus 1 specified by the address attached to the digital-signature-attached message (S7109).

In each digital signer side apparatus 1, the verification request processing section 112 waits for a request for transmission of a signature log list or verification results to be sent (S7201). When the verification request processing section 112 has received a request for transmission of a signature log list, the section reads the signature logs 2235 registered with the signature log table 2234 in the EEPROM 223, and sends them to the digital signature verifier side apparatus 5 (S7202). When the verification request processing section 112 has received verification results (S7203), the section displays the results using, for example, the display device 17 (S7204). Sending the verification results also to a digital signer side apparatus 1 as described above makes it possible to take such a measure as changing the secret key 2232 for generation of signatures when, for example, the verification results indicate that a third party somehow obtained the secret key 2232 and illegally generated a digital signature posing as a digital signer.

It should be noted that in this invention, as a method of sending a history log list from a digital signer side apparatus 1 to the digital signature verifier side apparatus 5, the IC card 22 itself may be sent by, for example, postal mail, in addition to the above method in which the history log list is transmitted through the network.

Next, referring to Fig. 6, description will be made of representative example processes in specific embodiments in which the digital signer side apparatus 1 asks the digital signature verifier side apparatus 5 to verify a digital-signature-attached message generated by the digital signer side apparatus 1 itself.

In a digital signer side apparatus 1, when a digital signer has entered the address of a purchaser side apparatus 3 that will purchase a digital-signature-attached message, through the input device 16, and has requested verification of the digital-signature-attached message, the verification request processing section 112 asks the digital verifier side apparatus 5 to verify the message by sending the entered address of the purchaser side apparatus 3 (S8001). Then, the verification request processing section 112 proceeds to step S8002 and performs processes at the flow of steps S7201 through S7204 shown in Fig. 5.

In the digital signature verifier apparatus 5, when the signature verification processing section 511 has received a request for verification of a digital-signature-attached message from a digital signer side apparatus 1, the section sends a request for transmission of the digital-signature-attached message to be verified and the address of



the digital signer side apparatus 1 that has sent the verification request, to the purchaser side apparatus 3 specified by the address sent with the verification request (S8101), and waits for the message to be transmitted (S8102). Then, the signature verification processing section 511 proceeds to step S8103 and performs processes at the flow of steps 5 S7101 through S7109 shown in Fig. 5.

In each purchaser side apparatus 3, the verification request processing section 312 waits for a request for transmission of a digital-signature-attached message to be verified, from the digital signature verifier side apparatus 5 (S8201). Then, from the external storage device 33 or the like, the section reads the digital-signature-attached 10 message acquired from the digital signer side apparatus 1 specified by the address sent with the request, and sends the message to the digital signature verifier side apparatus 5 (S8202). After that, the verification request processing section 312 proceeds to step S8203 and performs processes at the flow of steps S7002 through S7003 shown in Fig. 5.

According to this embodiment, each digital signer side apparatus 1 15 distributes a digital-signature-attached message that includes a digital signature and a message generated by the digital signer side apparatus 1 itself after registering a signature log 2235 that includes the digital signature and a hash value of the message, with the signature log table 2234.

The digital signature verifier side apparatus 5 acquires a log list made up 20 of registered signature logs 2235 from a digital signer side apparatus 1, and checks whether a signature log that includes a hash value of the message and the digital signature included in the digital-signature-attached message to be verified, is registered. Accordingly, the digital signature verifier side apparatus 5 can determine whether the digital-signature-attached message to be verified has been generated by the digital signer 25 side apparatus 1, and is valid, or a third party has illegally generated the message posing as a digital signer after somehow obtaining the secret key 2232.

In an alternative embodiment, a signature log table may be set in the external storage device 13 of the computer 21, in addition to the EEPROM 223. With this arrangement, when the number of signature logs registered with the signature log table in 30 the EEPROM 223 exceeds a predetermined value (this value may be set considering the capacity of the EEPROM 223) as a result of registering a newly generated signature log with the signature log table in EEPROM 223, the earliest log registered with the signature log table in the EEPROM 223 may be transferred to the signature log table in the external

storage device 13 before registering the above new signature log with the signature log table in the EEPROM 223.

In another embodiment, a plurality of signature logs registered with the signature log table in the EEPROM 223 may be registered with the signature log table in the external storage device 13 together at once. This registration of signature logs with the signature log table in the external storage device 13 may be performed when appropriate, according to the instructions of a signer, or the signature logs may be automatically registered each time the number of the signature logs reaches a predetermined value.

In still another embodiment, a newly generated signature log may be registered with both the signature log table in the EEPROM 223 and the signature log table in the external storage device 13 of the computer 21, and when the number of the signature logs registered with the signature log table in the EEPROM 223 exceeds a predetermined value as a result of registering the above newly generated signature log with the signature log table in the EEPROM 223, the earliest signature log registered with the signature log table in the EEPROM 223 may be deleted before registering the above newly generated signature log with the signature log table in the EEPROM 223.

In such specific embodiments, it is possible to realize digital signer side apparatus 1 even when the capacity of the EEPROM 223 is small.

In order to prevent a digital signer from altering a signature log, it is preferred that the signature log table set in the external storage device 13 is set so that the table can be written only from the IC card 22, or a non-rewritable storage medium such as a CD-R is used.

Further, instead of setting a signature log table in the EEPROM 223, a signature log management apparatus 9 may be newly added to the configuration shown Fig. 1 to manage the signature log table for each digital signer side apparatus 1. With this arrangement, each digital signer side apparatus 1 may register a signature log with the signature log table corresponding to each digital signer side apparatus 1 itself each time a digital signature is newly generated, or as is the case with registration with the signature log table in the external storage device 13, a plurality of signature logs may be registered together at once with a signature log table which is set in the signature log management apparatus 9 and corresponds to each digital signer side apparatus 1.

In this case, at step S7103 of a flow shown in Fig. 5, the digital signature verifier side apparatus 5 sends to the signature log management apparatus 9 a request for transmission of a signature log list, attaching the address of the digital signer side apparatus 1 that created a digital-signature-attached message to be verified, to the request.

- 5 Furthermore, steps S7201 and S7202 of a flow shown in Fig. 5 are performed by the signature log management apparatus 9. Upon receiving a request for transmission of a signature log list, the signature log management apparatus 9 sends to the digital signature verifier side apparatus 5 the signature log list of the digital signer side apparatus 1 specified by the address attached to the request. This prevents a digital signer from  
10 altering a signature log.

- It should be noted that the signature log management apparatus 9 may be created on the same computer as that on which the digital signature verifier side apparatus 5 resides, or the signature log management apparatus 9 may be created on both the same and a different computers so that signature logs may be initially managed by the signature  
15 log management apparatus on the same computer and when the number of signature logs has reached a predetermined value, they may be registered together at once with the signature log management apparatus on the different computer.

- When any privacy and other problems do not arise, signature log data in the signature log management apparatus 9 may be made public to other apparatuses  
20 connected through the network for a certain period of time or indefinitely after the signature is generated. It should be noted, however, that the system is assumed to be set so that the logs cannot be rewritten or deleted. With this, for example, a purchaser can make sure that the records of transactions related to the purchaser are reflected in logs of a signer. Furthermore, by managing signature logs so that they can be viewed from many  
25 other apparatuses, it becomes difficult for a signer to alter his or her own signature log data, resulting in improved reliability of the entire system. An apparatus for thus making signature log data public may be provided separately from the signature log management apparatus.

- Specific information may be set to each IC card 22 so that by using this  
30 information, it can be guaranteed that a registered signature log is produced surely for a signature generated by an IC card 22. For example, an IC card issuer secretly sets specific information to each IC card at the time of issuing the card, concealing it even from the signer who owns it. Each time a digital signature is generated by the IC card,

the specific information set to the IC card is used to generate a MAC (Message Authentication Code) for the digital signature by utilizing the information as a MAC-generation secret key, which is different from the secret key 2232 for generating a digital signature, and the MAC is registered with a signature log table, together with the signature log. A signature log list including this MAC is transmitted in response to a request for transmission of a signature log list from a digital signature verifier.

Adoption of the above method makes it difficult to alter a signature log. This is because a digital signature verifier can acquire specific information set to the IC card that generated the signature, from the IC card issuer beforehand or as necessary, and by checking the validity of the MAC using the acquired information, the verifier can detect alteration of the signature log. Furthermore, since information that even the signer does not know is used as a secret key, forging of a signature log by the signer itself also can be prevented.

In addition to storing a MAC in a signature log table, the MAC may be output to a purchaser together with a digital-signature-attached message so that it can be used as means for reinforcing the purchaser's capability to check the validity of a signature attached to a purchased message.

When there is provided the signature log management apparatus 9 in which a signature log table is set, it may be arranged such that the signature log management apparatus 9 also can acquire specific information set to an IC card that has generated a signature, from the IC card issuer beforehand or as necessary, so as to check the validity of the MAC when registering the signature log with the signature log table set in the signature log management apparatus 9, and register only a valid signature log. In this case, when an attempt is made to register a signature log whose MAC is not valid, an alarm may be sent to the signer or the entire system so that from now on, the secret key 2232 for signing and the signing system will not be used, regarding that it has become possible to forge a signature due to disclosure of the secret key or some other reason.

Instead of using specific information set to each IC card as a secret key for generating a MAC, the specific information can be used as a secret key for generating another digital signature so as to guarantee that a signature has surely been generated by use of a specific IC card 22, which also makes it difficult to forge a signature log as is the case with a MAC. The above method eliminates the need of acquiring specific information set to each IC card in order to verify that a signature has been generated by

use of an IC card 22, and, instead, requires only public-key information which corresponds to the specific information and is available to anyone. Therefore, unlike the use of a MAC, it is easy to employ this method as a means for helping a purchaser confirm the validity of a purchased message.

5 In the above method, from the viewpoint of avoiding the risk of forgery of digital signatures, which is increased by improved decryption algorithms, it is desirable to use a digital signing system different from one in which a digital signature is sent to a purchaser by attaching it to a message, that is, as a signature-attached message. Since from the viewpoint of reducing the scale of its implementation in the IC card 22, use of  
10 the same digital signing system is more advantageous, the signing system may be determined depending on conditions.

Since specific information set to each IC card is used as a secret key, dynamic update of the information, which means that the secret-key information is not fixed, offers the advantage of making it difficult to analyze the secret key. In the above  
15 method, to verify the validity of a signature log using specific information set to each IC card, it is necessary to know how to update the specific information. For example, after using specific information set to an IC card, a hash value of the specific information may be computed so that it can be used as new specific information to be set to the IC card.

Next, description will be made of a second embodiment of the present  
20 invention in which alteration of a signature log can be more effectively prevented. Each apparatus of a system in accordance with this embodiment basically has the same configuration as that for the first embodiment except for the components of signature logs 2235 stored in a signature log table 2234.

Although the same processes as those for the first embodiment, shown in  
25 Fig. 4, are performed when a purchaser side apparatus 3 acquires a digital-signature-attached message from a digital signer side apparatus 1, the contents of specific signature generation processing by the digital signer side apparatus 1 are different, and so are the contents of specific signature verification processing by the purchaser side apparatus 3.

In the digital signer side apparatus 1, a signature generation processing  
30 section 2211 generates a digital signature  $\text{Sign}_N$  by applying a secret key 2232 to a set of a hash value  $h(M_{N-1})$  of a message  $M_{N-1}$  and a digital signature  $\text{Sign}_{N-1}$  (this set “ $(h(M_{N-1}), \text{Sign}_{N-1})$ ” is referred to as previous data  $P_{N-1}$ ) included in a signature log 2235 generated in the last (N-1th) signature generation processing, and to a hash value  $h(M_N)$  of a

message  $M_N$  sent from a signature-attached message creation processing section 111 (S6102). When the initial (first) signature is generated, an initial value IV, which is set as a value common to the entire system or a value specific to each apparatus, may be used as previous data P0, or the initial previous data P0 may be omitted. The signature

5 generation processing section 2211 registers a signature log 2235 which is comprised of the previous data  $P_{N-1}$ , the hash value  $h(M_N)$  of the message, the digital signature  $Sign_N$ , and the address of a purchaser side apparatus 3 that has made a transmission request, with the signature log table 2234(S6103). The signature generation processing section 2211, then, sends the previous data  $P_{N-1}$ , the digital signature  $Sign_N$ , and a public key certificate  
10 2233 stored in an EEPROM 223 to the signature-attached message creation processing section 111. The signature-attached message creation processing section 111 creates a digital-signature-attached message by attaching the previous data  $P_{N-1}$  and the digital signature  $Sign_N$  to the message  $M_N$  to be transmitted, and transmits to the purchaser side apparatus 3 the digital-signature-attached message with the public key certificate 2233  
15 attached thereto (S6104).

In the above embodiment, when the digital signature  $Sign_N$  is generated, a hash value  $h(P_{N-1})$  of the previous data  $P_{N-1}$  may be used instead of the previous data itself. In this case, as data to be stored in the signature log table, the hash value  $h(P_{N-1})$  of the previous data  $P_{N-1}$  may also be used instead of the previous data itself. Furthermore,  
20 as previous data to be used for the Nth signature, the hash value  $h(M_{N-1})$  of the message  $M_{N-1}$ , the digital signature  $Sign_{N-1}$ , and, in addition, a hash value  $h(P_{N-2})$  of previous data  $P_{N-2}$ , which is used for the N-1th signature, are used as a three-component set. In addition, a hash function used to compute a hash value of previous data may be different from that used to compute a hash value of a message. It should be noted that when the  
25 previous data  $P_{N-1}$  can be computed from other data, as in the case where  $(h(M_{N-1}), Sign_{N-1})$  is used as the previous data  $P_{N-1}$ , instead of storing and then using  $P_i (0 < i < N-1)$ , previous data may not be stored but calculated as necessary to save the data storage area.

As a result of the above processing, each signature log 2235 stored in the signature log table 2234 comprises previous data, a hash value of a message, and a digital  
30 signature as shown in Fig. 7.

In the purchaser side apparatus 3, as a comparison target at comparison step S6003, instead of using only a hash value computed from the message included in a

digital-signature-attached message, a set of the hash value and the previous data included in the digital-signature-attached message is used.

Next, referring to Fig. 8, description will be made of representative example processes in specific embodiments in which a purchaser side apparatus 3 asks a digital signature verifier side apparatus 5 to verify a digital-signature-attached message acquired from a digital signer side apparatus 1. It should be noted that the following description explains an example of verification processes performed in the condition that the determination of “forged” is disadvantageous to the signer.

Processes at steps S11001, S1102, and S11003 in Fig. 8 are the same as those at steps S7001, S7002, and S7003 in Fig. 5, respectively.

When a verification request processing section 312 has received a request for transmission of a digital-signature-attached message to be used as a reference material from the digital signature verifier side apparatus 5 (S11101), the section reads the digital-signature-attached message acquired from the digital signer side apparatus 1 specified by the address attached to the request, from, for example, an external storage device 33 or the like, and transmits the message to the digital signature verifier side apparatus 5 (S11102).

In the digital signature verifier side apparatus 5, a signature verification processing section 511 performs the first-stage verification, using the digital signature included in the digital-signature-attached message and the public key of the public key certificate 2233 attached to the digital-signature-attached message (S11201). When the signature is authenticated (if the result is OK at step S11202), the processes at steps S11203 and S11204, which are the same as those at steps S7103 and S7104, are performed. When the signature is not authenticated (if the result is NG at step S11202), on the other hand, the process at step S11214, which is the same as that at step S7108, is performed.

The signature verification processing section 511 performs the second-stage verification of the digital-signature-attached message. Specifically, the section checks whether a signature log that includes the digital signature and the previous data included in the digital-signature-attached message and a hash value of a message acquired at step S11201 is registered with an acquired signature log list (S11205).

If the signature log is registered (if the result is OK at step S11206), the signature verification processing section 511 makes the same determination as that at step

7106, and performs the third-stage verification of the digital-signature-attached message. Specifically, the signature verification processing section 511 reads the message hash value and the digital signature included in the signature log registered immediately before the signature log corresponding to the verification target digital-signature-attached message in the signature log list acquired at step S11204. For example, in Fig. 7, when the Nth signature log includes the digital signature and the previous data included in the verification target digital-signature-attached message and the message hash value acquired at step 11201, the signature verification processing section 511 reads the message hash value and the digital signature included in the N-1th signature log. The signature verification processing section 511 compares both the message hash value and the digital signature included in the immediately previous registered signature log, against the previous data included in the verification target digital-signature-attached message. As described above, the previous data is comprised of the message hash value and the digital signature included in the immediately previous registered signature log (S11207).

When they do not coincide (if the result is NG at step S11208), the signature verification processing section 511 authenticates that the signature log corresponding to the verification target digital-signature-attached message has been altered, and transmits the results to the purchaser side apparatus 3 that has transmitted the verification request and to the digital signer side apparatus 1 specified by the address attached to the digital-signature-attached message (S11216). When they coincide (if the result is OK at step S11206), the section proceeds to step S11209.

At step S11209, the signature verification processing section 511 sends a request for transmission of a digital-signature-attached message to be used as a reference material, to the purchaser side apparatus 3 specified by the purchaser address included in the signature log registered immediately before the signature log corresponding to the verification target digital-signature-attached message, attaching the address of the digital signer side apparatus 1 that has transmitted the verification request, to the request, and waits for the message to be transmitted (S11210).

The signature verification processing section 511 performs the fourth-stage verification of the digital-signature-attached message acquired as a reference material.

Specifically, the section computes a hash value of the message included in the digital-signature-attached message acquired at step S11210. Then, the signature verification processing section 511 checks whether the digital signature and the previous



data included in the digital-signature-attached message acquired at step S11210 and the hash value of the message coincide with the contents of the signature log registered immediately before the signature log corresponding to the verification target digital-signature-attached message, in the signature log list acquired at step S11204 (S11211).

5                   When they do not coincide (if the result is NG at step S11212), the signature verification processing section 511 determines that both the signature log corresponding to the verification target digital-signature-attached message and the immediately previous registered signature log corresponding to the digital-signature-attached message used as a reference material may have been altered, producing the third-  
10   stage verification result OK at step S11208, and transmits the results to the purchaser side apparatus 3 that has transmitted the verification request and to the digital signer side apparatus 1 specified by the address attached to the digital-signature-attached messages (S11217). When they coincide (if the result is OK at step S11212), on the other hand, the signature verification processing section 511 authenticates that the verification target  
15   digital-signature-attached message has been generated by the digital signer side apparatus 1 that provided the signature log list and the message is valid, and transmits the results to the purchaser side apparatus 3 that has transmitted the verification request and to the digital signer side apparatus 1 specified by the address attached to the digital-signature-attached messages (S11213). In the digital signer side apparatus 1, the processes  
20   performed at steps S11301 through S11305 are the same as those at steps S7201 through S7204.

Next, referring to Fig. 9, description will be made of representative example processes in specific embodiments in which a digital signer side apparatus 1 asks the digital signature verifier side apparatus 5 to verify a digital-signature-attached  
25   message that the digital signer side apparatus 1 has generated.

In the digital signer side apparatus 1, the process performed at step S12001 is the same as that at step S8001, and at step S12002, processes at the flow of steps S11301 through S11305 shown in Fig. 8 are performed.

In the digital signature verifier side apparatus 5, the processes performed at  
30   steps S12101 and S12102 are the same as those at steps S8101 and S8102, and at step S12103, the processes at the flow of steps S11201 through S11217 shown in Fig. 8 are performed.

In a purchaser side apparatus 3, the processes performed at steps S12201 and S12203 are the same as those at steps S8201 and S8202, and at S12204, processes at steps S11002 through S11003 shown in Fig. 8 are performed.

When the purchaser side apparatus 3 has received a request for  
 5 transmission of a digital-signature-attached message to be used as a reference material from the digital signature verifier apparatus 5 (the process at step S12202 performed if the result is NO at step S12201), the verification request processing section 312 reads the digital-signature-attached message to be used as a reference material, acquired from the digital signer side apparatus 1 specified by the address attached to the request, and  
 10 transmits the message to the digital signature verifier side apparatus 5 (S12205).

In this embodiment, the validity of a digital-signature-attached message can be more surely checked.

The third-stage signature verification according to the above embodiment checks the matching of the signature log corresponding to a verification target digital-  
 15 signature-attached message, which is expressed as Nth signature log, with the immediately previous N-1th signature log (whether mutual consistency is maintained). Similarly, the matching of the N-1th signature log with the immediately previous N-2th signature log may be further checked. By repeating this, mutual consistency of more signature logs included in a signature log list may be checked so as to more surely ensure  
 20 the reliability of the signature log list.

Further, in the third-stage signature verification according to the above embodiment, a series of an arbitrary number of signature logs including the signature log corresponding to a verification target digital-signature-attached message may be selected from the signature logs registered with the signature log table 2234. And for the series of  
 25 signature logs, the third-stage signature verification may check whether the previous data included in a signature log coincides with the digital signature and the message hash value included in the immediately previous signature log in order to detect alteration of a signature log.

Alteration of a signature log can also be detected by checking whether the  
 30 message hash value of a digital-signature-attached message is reflected in digital signatures included in one or more signature logs registered after the signature log corresponding to the digital-signature-attached message.

In this embodiment, to forge a past electronic signature, it is necessary to forge one or more electronic signatures created before or after the creation of the electronic signature to be forged, while maintaining their consistency. This increases the difficulty of forging a past electronic signature, making it difficult to attack on authorized business operators by forging their signatures. An authorized business operator also can put himself or herself in a position in which it is difficult for the operator to forge an alibi for any illegal conduct, which makes more persuasive to a mediator the assertion that the operator is not involved in any illegal conduct when the operator has suffered a malicious attack.

In the above embodiment, when the second-stage signature verification proves that signature data included in a verification target digital-signature-attached message is not included in a signature log list provided by the signer, it is determined that the digital signature to be verified is forged, while when the second-stage signature verification proves that the signature data is included in the signature log list, the third-stage and the fourth-stage verifications are performed to verify the validity of the signature log list. This is because when the determination of “forged” is disadvantageous to a signer who provides a signature log list, it is unthinkable for the signer to provide a forged signature log list.

In the case where the determination of “a signature is valid” is disadvantageous to a signer who provides a signature log list, on the other hand, when the second-stage signature verification proves that signature data to be verified is included in a submitted signature log list, it may be determined that the digital signature is valid, while when the signature data is not included in the signature log list, the third-stage and the fourth-stage verifications may be performed to verify the validity of the signature log list.

Or, after receiving a signature log list at step S11204, the signature verification processing section may first check the validity of the signature log list, and after the validity is confirmed, if signature data to be verified is included in the valid signature log list, it may be determined that the signature is valid.

When a signer cannot submit a signature log list in full to a verifier due to data corruption or some other reason, not all of the information provided by the submitted signature log list (with its some part missing) is generally reliable. However, by using the

following method, it is possible to extract reliable signature logs from the sent information.

In the digital signature verifier side apparatus 5, of the signature logs included in the submitted signature log list, those that prove to be in areas which cannot be controlled by the signer itself, can be regarded as reliable signature logs.

For example, signatures to be stored in the EEPROM 223 area as signature logs 2235 are automatically written when the signer generates the signatures by use of the IC card 22. Since this area is set so that it cannot be rewritten or deleted, the signer itself cannot control (alter) the area. Therefore, the logs corresponding to signatures stored in the EEPROM 223 area can be regarded as reliable.

Similarly, the signature logs corresponding to signatures stored in the signature log management apparatus 9 or the like that is a reliable third party can be regarded as reliable since the signer cannot control the signatures.

Furthermore, the signature log corresponding to a signature made public by newspapers, broadcasting, or the like, so that it has become known to many and unspecified people at some time point before a signature verifier verifies it, for example, immediately after it is generated by a signer, can be also regarded as reliable since after the above time point, it is very difficult for the signer to do anything so that it looks as if the signature had not existed, that is, the signer itself cannot control the past existence of the signature.

When another purchaser who is disinterested owns a signature (for example, as a signature log), the signature log is also regarded as reliable.

Further, if it is confirmed that a reliable signature log and the signature log registered immediately before the reliable signature log match, that is, they are consistent with each other, the immediately previous signature log also can be regarded as a reliable signature log. This is because, since in this invention a signature log includes a hash value of the immediately previous message or signature, it is very difficult to forge the immediately previous signature log so that it coincides with a hash value included in a reliable signature log even when it has become easy to forge the digital signature itself due to disclosure of a secret key or some other reason. By repeating this procedure, that is, going back through a series of signature logs, starting from a reliable signature log, while confirming that each signature log is consistent with the immediately previous one, the range of reliable signature logs included in a submitted log list can be determined

since the range of signature logs that are consistent with one another starting from a reliable signature log can be regarded as reliable.

According to above embodiment, a digital signer side apparatus 1 generates a digital signature by applying a secret key 2232 to a previous data  $P_{N-1}$ , and to a hash value of  $h(M_N)$  of a message  $M_N$ . Similarly, a digital signer side apparatus 1 may generate a digital signature by applying a secret key 2232 to other data in addition to a previous data and a hash value of a message. For example, a digital signer side apparatus may generate a digital signature by applying a secret key 2232 to a public key certificate 2233, which is sent to a purchaser side apparatus 3, or its hash value, and to a previous data, and to a hash value of a message. This makes it easy to prove later that the public key certificate existed when the digital signature was generated. That is, because it is very difficult to forge the signature log, which is reflected by the public key certificate, so that its hash value coincides with a hash value included in immediately after signature log, this makes it easy to prove that there existed the public key certificate even when it has become easy to forge a certificate which was issued by certificate authority. Further, any data, which is intended to prove that it exists when the signature is generated, may be used as well as a certificate. In order to be verified the signature by a purchaser side apparatus 3, the data, or modified data which makes it possible to verify the signature (e.g. a hash value of the data), is sent to a purchaser side apparatus 3 together with a message and a signature.

As in the embodiments described herein above, a signature log table 2234 may be set in an external storage device 13 of a computer 21, in addition to the EEPROM 223.

Instead of setting the signature log table 2234 in the EEPROM 223, the signature log management apparatus 9 may be provided to manage the signature log table for each digital signer side apparatus 1, as described earlier.

As in the embodiments described herein above, this signature log management apparatus 9 may be created on the same computer as that on which the digital signature verifier side apparatus 5 resides.

As in the embodiments described herein above, specific information (a serial number or the like) may be set to each IC card so that by using this information, specific data may be generated to guarantee that a signature has surely been generated by use of the IC card.

When there is provided the signature log management apparatus 9, processes at the flow of steps S11207 and S11208 shown in Fig. 8 (the third-stage signature verification) may be performed by the signature log management apparatus 9 before registering a signature log with a signature log list so that only when the previous data included in the signature log coincides with the message hash value and the signature included in the latest signature log data registered with the signature log list, is the signature log permitted to be registered with the signature log list. In this case, in the digital signature verifier side apparatus 5, the flow of steps S11207 and S11209 shown in Fig. 8 (the third-stage signature verification) can be omitted.

As in the embodiments described herein above, a plurality of signature logs may be registered together at once with a signature log list managed by the signature log management apparatus 9. In this case, in addition, a message indicating registration with the signature log list may be created, and a signature may be generated for this message so that the registration with the signature log list is reflected in the signature log list of the digital signer side apparatus 1.

Next, description will be made of a third embodiment, in which, in addition to the first embodiment, time information is further included in each digital signature so as to verify the validity of the digital signature also using this time information.

This system is configured so that a timestamp issuing apparatus 8, which issues a timestamp for a digital signature sent from each digital signer side apparatus 1, is added to a system according to the first embodiment shown in Fig. 1.

The schematic configuration of the timestamp issuing apparatus 8 is the same as that shown in Fig. 2.

An external storage device 13 stores a timestamp issuing program 831, which generates a timestamp by encrypting a digital signature and time data sent from a digital signer side apparatus 1, a secret key 832 used to generate a timestamp, and a public key certificate 833 containing a public key paired with the secret key 832. These are loaded into a RAM 12, and are executed by a CPU 11 as a process called a timestamp issuance processing section 811.

Referring to Fig. 10, description will be made of representative example processes in specific embodiments in which a purchaser side apparatus 3 acquires a digital-signature-attached message from a digital signer side apparatus 1.

The digital signer side apparatus 1 performs processes at steps S6101 through S6103 shown in Fig. 4 (S15101). A signature-attached message creation processing section 111 asks the timestamp issuing apparatus 8 to issue a timestamp by transmitting a digital signature sent from a signature generation processing section 2211 to the timestamp issuing apparatus 8 (S15102). When the signature-attached message creation processing section 111 has received a timestamp from the timestamp issuing apparatus 8 (S15103), the section creates a digital-signature-attached message by attaching the timestamp to a message to be transmitted, and transmits the time stamped message to the purchaser side apparatus 3 that has requested the transmission, attaching both the public key certificate 2233 sent with the digital signature from the signature generation processing section 2211 and the public key certificate 833 sent with the timestamp from the timestamp issuing apparatus 8, to the time stamped message (S15104).

In the timestamp issuing apparatus 8, upon receiving a digital signature from a digital signer side apparatus 1, the timestamp issuance processing section 811 generates a timestamp (S15201). Specifically, the section generates a timestamp by encrypting the digital signature sent from the digital signer side apparatus 1, and time data indicating the reception time of the digital signature by use of the secret key 832 stored in an external storage device 83. The timestamp issuance processing section 811 attaches the public key certificate 833 stored in the external storage device 83 to the generated timestamp, and transmits the certificate-attached timestamp to the digital signer side apparatus 1 that has transmitted the digital signature (S15202).

The purchaser side apparatus 3 acquires a digital-signature-attached message by performing the processes at steps S6001 through S6002 shown in Fig. 4 (S15001). Next, a signature-attached message acquisition processing section 311 acquires a digital signature by decrypting the timestamp included in the received digital-signature-attached message, using the public key (the public key of the timestamp issuance apparatus 8) of a public key certificate 821 attached to the message (S15002). Then, the signature-attached message acquisition processing section 311 performs the processes at steps S6004 through S6006 to verify the digital signature (S15003).

Referring to Fig. 11, description will be made of representative example processes in specific embodiments in which a purchaser side apparatus 3 asks a digital

signature verifier side apparatus 5 to verify a digital-signature-attached message acquired from a digital signer side apparatus 1.

Incidentally, in this embodiment, it is assumed that when a digital signer, who is a user of a digital signer side apparatus 1, has found that a secret key 2232 which the digital signer secretly holds has been disclosed and a third party may have illegally obtained the secret key, the digital signer notifies a digital signature verifier of the disclosure, specifying its date and time. Then, the digital signature verifier stores the date and time given by the digital signer and the address of the digital signer side apparatus 1 used by the digital signer, as a set, in an external storage device 53 of the digital signature verifier apparatus 5.

A verification request processing section 312 performs the processes at the flow of steps S7001 through S7003 shown in Fig. 5 to acquire verification results from the digital signature verifier side apparatus 5 (S16001).

In the digital signature verifier side apparatus 5, when a signature verification processing section 511 has received a request for verification of a digital-signature-attached message from a purchaser side apparatus 3, the section decrypts the timestamp included in the digital-signature-attached message sent with the request, using the public key (the public key of the timestamp issuing apparatus 8) of the public key certificate 821 attached to the digital-signature-attached message to acquire time data and a digital signature (S16101).

The signature verification processing section 511 checks the external storage device 53 to see whether disclosure date and time of the secret key 2232 is set for the digital signer side apparatus 1 specified by the address attached to the digital-signature-attached message (S16102). When the disclosure date and time has been set, the signature verification processing section 511 proceeds to step S16103, while when no disclosure date and time has been set, the section proceeds to step S16105 and performs the processes at steps S7101 through S7109 shown in Fig. 5.

At step S16103, the signature verification processing section 511 checks whether the date and time indicated by the time data acquired at step S16101 is later than the disclosure date and time set in the external storage device 53 (S16103). If it is later than the disclosure date and time, the signature verification processing section 511 determines that the digital-signature-attached message to be verified is invalid, and transmits the results to the purchaser side apparatus 3 that has transmitted the verification



request and to the digital signer side apparatus 1 specified by the address attached to the digital-signature-attached message (S16104). If it is not later than the disclosure date and time, on the other hand, the section proceeds to step S16105 and performs the processes at steps S7101 through S7109.

5 In the digital signer side apparatus 1, a verification request processing section 112 performs the processes at steps S7201 through S7204 shown in Fig. 5 (S16201).

Next, description will be made of representative example processes in specific embodiments in which a digital signer side apparatus 1 asks the digital signature  
10 verifier side apparatus 5 to verify a digital-signature-attached message that the digital signer side apparatus 1 has generated.

The digital signer side apparatus 1 performs the same processes as those at steps S8001 through S8002 shown in Fig. 6.

In the digital signature verifier side apparatus 5, when the signature  
15 verification processing section 511 has received a request for verification of a digital-signature-attached message from a digital signer side apparatus 1, the section asks the purchaser side apparatus 3 specified by the address sent with the request to transmit the digital-signature-attached message with the address of the digital signer side apparatus 1 that has transmitted the verification request, attached thereto, and waits for the message to  
20 be sent. Then, the signature verification processing section 511 performs the processes at steps S16101 through S16105 shown in Fig. 11.

The purchaser side apparatus 3 performs the same processes as those at steps S8201 through S8203 shown in Fig. 6.

According to this embodiment, the digital signature verifier side apparatus  
25 5 acquires a digital signature and time data by decrypting the timestamp included in a digital-signature-attached message to be verified, using the public key of the time stamping authority side apparatus 8. By checking whether date and time indicated by this time data is later than disclosure date and time given by a digital signature generator, it is possible to check the validity of the digital signature before verifying the digital signature.

30 In the above embodiment, the digital signer side apparatus 1 may send a request for issuance of a timestamp at intervals (for example, once every  $m$  digital signatures). To verify the validity of a digital-signature-attached message with no

timestamp attached thereto, based on disclosure date and time given by a digital signature generator, the following method is used:

After a digital signer side apparatus 1 asks the timestamp issuing apparatus 8 to issue a timestamp by sending a digital signature to the timestamp issuing apparatus 8, the digital signer side apparatus 1 includes the timestamp sent from the timestamp issuing apparatus 8 into a signature log 2235 corresponding to the digital signature to which the timestamp is applied, and registers the signature log 2235 with a signature log table 2234 as shown in Fig. 12. It should be noted that signature logs are registered with the signature log table 2234 in the chronological order.

The digital signature verifier apparatus 5 searches the signature log table 2234 for a signature log which is registered before the signature log corresponding to a digital-signature-attached message to be verified and which includes a timestamp, and decrypts the timestamp to acquire its time data. Since signature logs are registered with the signature log table 2234 in the chronological order, the digital-signature-attached message to be verified was generated after date and time indicated by the decrypted time data. Therefore, if disclosure date and time given by the digital signer is earlier than the date and time indicated by this decrypted time data, the digital-signature-attached message to be verified is determined to be invalid.

Furthermore, in the second embodiment also, a timestamp can be used to determine the validity of a digital signature. Determination of the validity of a digital signature by use of a timestamp can be realized independently from the first embodiment and the second embodiment.

Different from each of the above embodiments, a message itself may be included in each signature log 2235 when the storage device storing the signature log table 2234 has spare capacity.

Different from each of the above embodiments, all processes to be performed by each digital signer side apparatus 1 may be performed inside a computer 21.

Different from each of the above embodiments, various signing methods which use a digital signature, a message (and previous data in the case of the second embodiment), and a public key paired with a secret key owned by a digital signer to authenticate whether said digital signature has been generated for said message, can be applied to the present invention.

As described above, the present invention can provide a digital signature technique which can discriminate a digital signature generated by a digital signature generator from a digital signature generated by a third party posing as the digital signature generator.

5           The preceding has been a description of the preferred embodiment of the invention. It will be appreciated that deviations and modifications can be made without departing from the scope of the invention, which is defined by the appended claims.

What is claimed is:

- 1                   1.       A digital signing method, comprising:  
2                   applying a secret key to a message to generate a digital signature for the  
3                   message;  
4                   distributing a digital-signature-attached message including the generated  
5                   digital signature and the message;  
6                   registering the digital-signature-attached message as log data with a log  
7                   list; and  
8                   providing said log list responsive to a request.
- 1                   2.       The digital signing method of claim 1, wherein said message is a  
2                   hash value of another message.
- 1                   3.       The digital signing method of claim 1, wherein:  
2                   said applying a secret key to a message to generate a digital signature for  
3                   the message further comprises:  
4                   applying said secret key to a message and data from a previously signed  
5                   message retrieved from a recent log data registered in said log list to generate a digital  
6                   signature for the message; and wherein:  
7                   said distributing a digital-signature-attached message including the  
8                   generated digital signature and the message, further comprises:  
9                   distributing a digital-signature-attached message including the generated  
10                  digital signature, the data from a previously signed message, and the message.
- 1                   4.       The digital signing method of claim 1, wherein said log data further  
2                   comprises a distribution destination, and wherein:  
3                   said registering log data of the digital-signature-attached message with a  
4                   log list further comprises:  
5                   registering log data of a digital-signature-attached message with a log list,  
6                   said log data including a distribution destination attached thereto.
- 1                   5.       The digital signing method of claim 1, said method further  
2                   comprising:

3                   permitting registration of the log data with said log list only when the data  
4   from a previously signed message included in said digital-signature-attached message is  
5   included in the latest log data registered with said log list.

1                   6.     The digital signing method of claim 1, further comprising:  
2                   obtaining a timestamp from a trusted authority, said timestamp generated  
3   by applying a second secret key to the digital signature, and a time; and  
4                   said distributing a digital-signature-attached message including the  
5   generated digital signature and the message, further comprises:  
6                   distributing a digital-signature-attached message including the generated  
7   digital signature, the timestamp, and the message.

1                   7.     A digital signature verifying method, comprising:  
2                   accepting a digital-signature-attached message;  
3                   acquiring a log list of a digital signer, wherein said digital-signature-  
4   attached message may have been distributed by said digital signer is to be verified; and  
5                   checking whether log data of said digital-signature-attached message is  
6   registered in said log list, and  
7                   if the log data is registered in the log list, authenticating that the digital-  
8   signature-attached message was distributed by the digital signer.

1                   8.     The digital signature verifying method of claim 7, said method  
2   further comprising:  
3                   checking whether the digital signature included in the digital-signature-  
4   attached message has been generated for the message included in the digital-signature-  
5   attached message, using the digital signature and the message included in said digital-  
6   signature-attached message and a public key paired with a secret key of said digital  
7   signer.

1                   9.     The digital signature verifying method of claim 7, wherein said  
2   digital-signature-attached message further comprises data from a previously signed  
3   message, said method further comprising:  
4                   checking whether the digital signature included in the digital-signature-  
5   attached message has been generated for the message included in the digital-signature-  
6   attached message, using the digital signature, the data from a previously signed message,

7 and the message included in said digital-signature-attached message and a public key  
8 paired with a secret key of said digital signer.

1           10.    The digital signature verifying method of claim 9, said method  
2 further comprising:  
3           checking whether data from a previously signed message included in said  
4 digital-signature-attached message is included in the log data registered immediately  
5 before log data of said digital-signature-attached message in said log list, and if the data  
6 from a previously signed message is included in the immediately previous registered log  
7 data, authenticating that said log list has not been altered.

1           11.    The digital signature verifying method of claim 7, wherein said log  
2 data further comprises a distribution destination, said method further comprising:  
3           acquiring a digital-signature-attached message from the distribution  
4 destination attached to the log data registered immediately before/after the log data of  
5 said digital-signature-attached message in said log list, and  
6           checking whether the acquired message is included in said immediately  
7 previous/subsequent registered log data, and if the message is included, authenticating  
8 that said log list has not been altered.

1           12.    The digital signature verifying method of claim 7, wherein said  
2 digital-signature-attached message further comprises a timestamp created using a second  
3 secret key, said method further comprising:  
4           acquiring a digital signature and a time data by applying a public key  
5 paired with said second secret key to the timestamp included in said digital-signature-  
6 attached message; and  
7           checking whether date and time indicated by the acquired time data  
8 exceeds a date and time of signing of said digital-signature-attached message, and if the  
9 date and time indicated by the time data does not exceed the date and time of signing of  
10 said digital-signature-attached message, authenticating the validity of the acquired digital  
11 signature.

1           13.    A digital signing apparatus, comprising:  
2           a processor; and

3 a storage medium; wherein said processor applies a secret key to a  
 4 message to generate a digital signature for the message; and wherein  
 5 said processor prepares a digital-signature-attached message including the  
 6 generated digital signature and the message; and wherein  
 7 said processor registers log data of said digital-signature-attached message  
 8 with a log list in said storage medium.

1 14. The digital signing apparatus of claim 13, wherein, said message is  
 2 a hash value of another message.

1 15. The digital signing apparatus of claim 13, wherein  
 2 said processor applies said secret key to a message and data from a  
 3 previously signed message retrieved from a recent log data registered in said log list to  
 4 generate a digital signature for the message; and wherein  
 5 said processor prepares a digital-signature-attached message that includes  
 6 the generated digital signature, the message and the data from a previously signed  
 7 message; and wherein  
 8 said processor registers log data of a digital-signature-attached message  
 9 including the generated digital signature, the message, and the data from a previously  
 10 signed message, with said log list.

1 16. The digital signing apparatus of claim 13, wherein said log data  
 2 further comprises a distribution destination, and wherein:  
 3 said processor registers log data of a digital-signature-attached message  
 4 with a log list, said log data including a distribution destination attached thereto.

1 17. The digital signing apparatus of claim 13, wherein:  
 2 registration of the log data with said log list is permitted only when the  
 3 data from a previously signed message included in said digital-signature-attached  
 4 message is included in the latest log data registered with said log list.

1 18. The digital signing apparatus of claim 13, wherein:  
 2 said processor obtains a timestamp from a trusted authority, said  
 3 timestamp generated by applying a second secret key to the digital signature, and a time;  
 4 and

5                   said processor prepares said digital-signature-attached message including  
6 the generated digital signature, the timestamp, and the message.

1                   19.     The digital signing apparatus of claim 13, further comprising: an  
2 interface configured to be connectable to a computer.

1                   20.     The digital signing apparatus of claim 19, wherein:  
2                   if a number of the log data registered with the log list exceeds a particular  
3 value, said processor outputs at least one of a plurality of log data registered with the log  
4 list to said computer, whereupon said computer registers said at least one of a plurality of  
5 log data with a second log list prepared in said computer, and thereupon,  
6                   said processor deletes said at least one of a plurality of log data from said  
7 log list in said storage medium.

1                   21.     A digital signature verifying apparatus, comprising:  
2                   a processor interconnected with an input device, wherein:  
3                   said input device accepts a digital-signature-attached message to be  
4 verified and a log list of a digital signer; and wherein  
5                   said processor checks whether log data of said digital-signature-attached  
6 message is registered with said log list, and  
7                   if the log data is registered with the log list, authenticates that the digital-  
8 signature-attached message has been generated by said digital signer.

1                   22.     A digital signature verifying apparatus of claim 21, wherein:  
2                   said processor authenticates whether the digital signature included in said  
3 digital-signature-attached message has been generated for the message included in the  
4 digital-signature-attached message, using the digital signature and the message included  
5 in said digital-signature-attached message and a public key paired with a secret key of  
6 said digital signer.

1                   23.     A digital signature verifying apparatus of claim 21, wherein said  
2 digital-signature-attached message further comprises data from a previously signed  
3 message, and wherein  
4                   said processor authenticates whether the digital signature included in said  
5 digital-signature-attached message has been generated for the message included in the



6 digital-signature-attached message, using the digital signature, the data from a previously  
 7 signed message, and the message included in said digital-signature-attached message and  
 8 a public key paired with a secret key of said digital signer.

1           24.    A digital signature verifying apparatus of claim 23, wherein  
 2                said processor checks whether the data from a previously signed message  
 3 included in said digital-signature-attached message is included in the log data registered  
 4 immediately before the log data of said digital-signature-attached message in said log list,  
 5 and if the data from a previously signed message is included in the immediately previous  
 6 registered log data, said processor authenticates that said log list has not been altered.

1           25.    The digital signature verifying apparatus of claim 21, wherein said  
 2 log data further comprises a distribution destination, and wherein:  
 3                said processor acquires a digital-signature-attached message from the  
 4 distribution destination attached to the log data registered immediately before/after the  
 5 log data of said digital-signature-attached message in said log list, and wherein  
 6                said processor checks whether the acquired message is included in said  
 7 immediately previous/subsequent registered log data, and if the message is included, said  
 8 processor authenticates that said log list has not been altered.

1           26.    The digital signature verifying apparatus of claim 21, wherein said  
 2 digital-signature-attached message further comprises a timestamp created using a second  
 3 secret key, and wherein:  
 4                said processor acquires a digital signature and a time data by applying a  
 5 public key paired with said second secret key to the timestamp included in said digital-  
 6 signature-attached message; and wherein  
 7                said processor checks whether date and time indicated by the acquired  
 8 time data exceeds a date and time of signing of said digital-signature-attached message,  
 9 and if the date and time indicated by the time data does not exceed the date and time of  
 10 signing of said digital-signature-attached message, said processor authenticates the  
 11 validity of the acquired digital signature.

1           27.    A computer program product for creating a digital signature, said  
 2 program product comprising:

3                   code that applies a secret key to a message to generate a digital signature  
 4 for the message;  
 5                   code that prepares a digital-signature-attached message including the  
 6 generated digital signature and the message;  
 7                   code that registers log data of said digital-signature-attached message with  
 8 a log list in said storage medium; and  
 9                   a computer readable storage medium for embodying the codes.

1                   28.    A computer program product of claim 27, wherein the computer  
 2 readable storage medium is a computer readable medium for storing the codes.

1                   29.    A computer program product of claim 27, wherein the computer  
 2 readable storage medium is a computer readable medium for transmitting the codes.

1                   30.    A computer program product for verifying a digital signature, said  
 2 computer program product comprising:  
 3                   code that accepts a digital-signature-attached message and a log list from a  
 4 digital signer; and  
 5                   code that checks whether log data of said digital-signature-attached  
 6 message is registered with said log list, and if the log data is registered with the log list,  
 7 authenticates that the digital-signature-attached message has been generated by said  
 8 digital signer; and  
 9                   a computer readable storage medium for storing the codes.

1                   31.    A digital timestamp issuing apparatus, comprising:  
 2 a processor and an interface, wherein  
 3 said processor generates a timestamp by applying a secret key to data  
 4 received by said interface, said data comprising a digital signature sent from a digital  
 5 signer, and a reception time of the digital signature; and wherein  
 6 said processor transmits said timestamp to said digital signer using said  
 7 interface.

1                   32.    A digital signing system, said system comprising:  
 2 a digital signing apparatus;  
 3 a timestamp issuing apparatus;

4                   said digital signing apparatus comprising:  
 5                   a processor and a communication interface, wherein said processor applies  
 6 a first secret key to a message or its hash value to generate a digital signature; and  
 7                   said processor transmits said digital signature to said timestamp issuing  
 8 apparatus by said communication interface and acquires a timestamp in response; and  
 9 wherein  
 10                  said processor attaches the acquired timestamp to said message to create a  
 11 digital-signature-attached message; and  
 12                  said timestamp issuing apparatus comprising:  
 13                  a processor and a communication interface, wherein  
 14                  said processor generates a timestamp by applying a second secret key to  
 15 data which includes the digital signature sent by said digital signing apparatus, and a  
 16 reception time of the digital signature; and wherein said processor  
 17                  transmits said timestamp to said digital signing apparatus.

1                   33.     The digital signing system of claim 32, said system further  
 2 comprising:  
 3                   a digital signature verifying apparatus comprising:  
 4                   a processor interconnected with an input device, wherein  
 5                   said input device accepts a digital-signature-attached message to be  
 6 verified; and wherein  
 7                   said processor acquires a digital signature and time data by applying a  
 8 public key paired with the secret key of the timestamp apparatus to the timestamp  
 9 included in said digital-signature-attached message; and thereupon,  
 10                  said processor checks whether date and time indicated by the time data  
 11 exceeds expiration date and time assigned at said digital signing apparatus, and when the  
 12 date and time indicated by the time data does not exceed the expiration date and time,  
 13 said processor authenticates the validity of the said digital signature; and thereupon,  
 14                  said processor authenticates whether said digital signature included in said  
 15 digital-signature-attached message has been generated for the message included in said  
 16 digital-signature-attached message, using said digital signature, the message included in  
 17 said digital-signature-attached message, and a public key paired with the secret key of the  
 18 digital signing apparatus.

## DIGITAL SIGNING METHOD

### ABSTRACT OF THE DISCLOSURE

According to the invention, techniques for authenticating that a digitally signed document is genuine. Specific embodiments according to the present invention

5 can determine whether a digital signature was generated by a digital signature generator, or if the digital signature was generated by a third party posing as the digital signature generator. Specific embodiments can provide independent verification of digital signer identity based upon prior signed messages, time/date stamps, and the like. Techniques

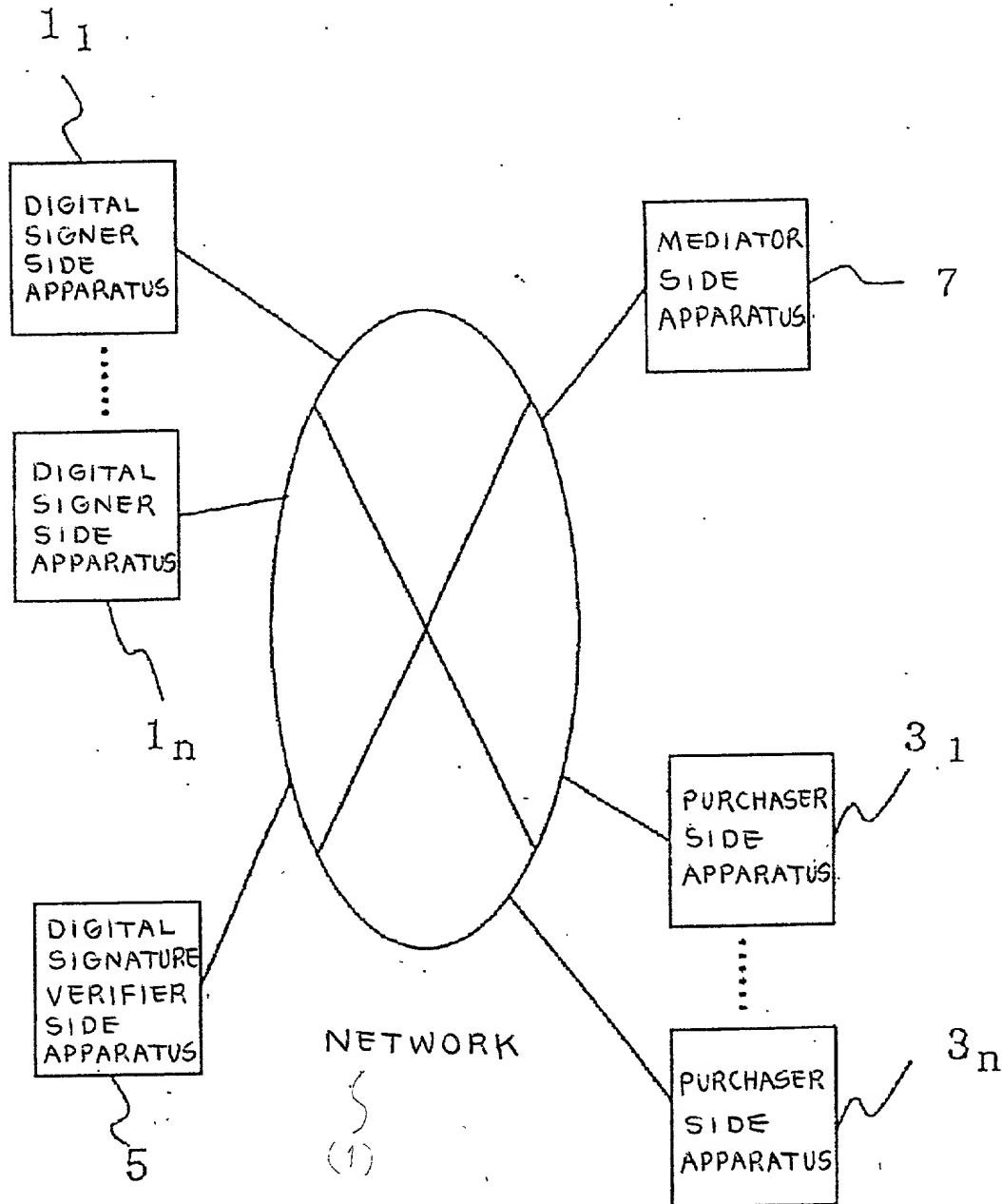
10 according to the present invention can be embodied in methods, apparatus, computer software and systems.

PA 3103006 v1

【書類名】 図面

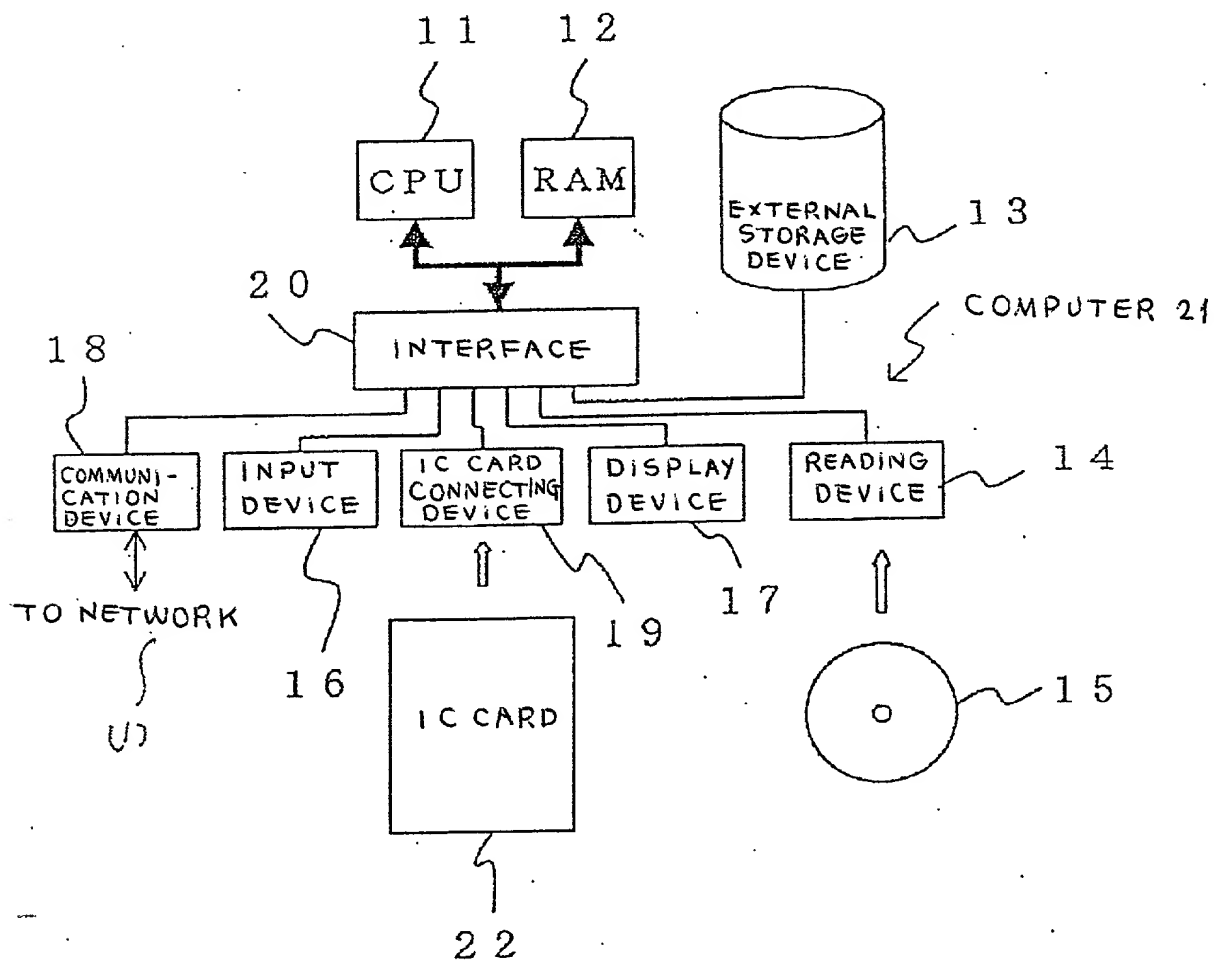
【図 1】

FIG. 1



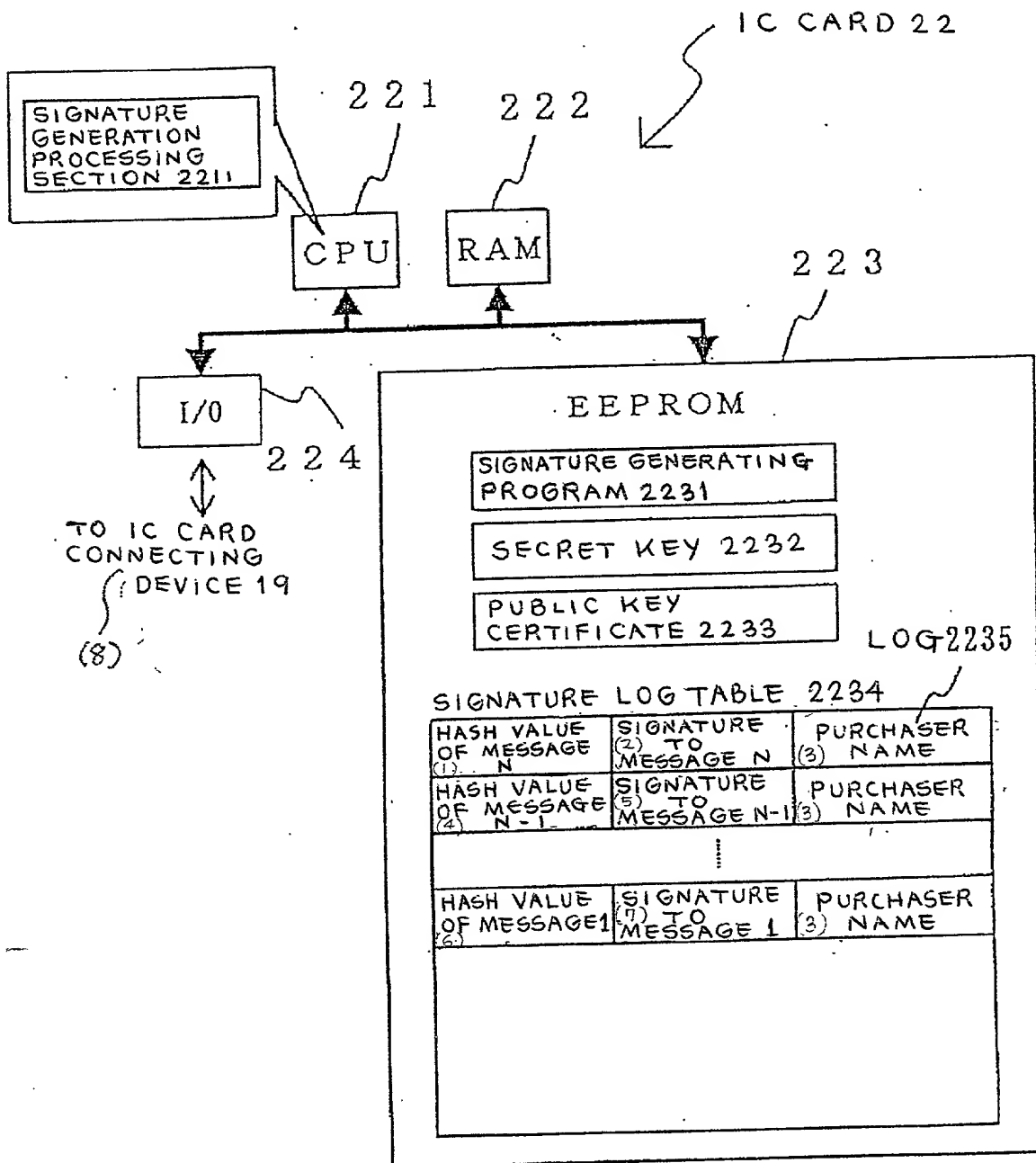
【図 2】

FIG. 2



[ 図 3 ]

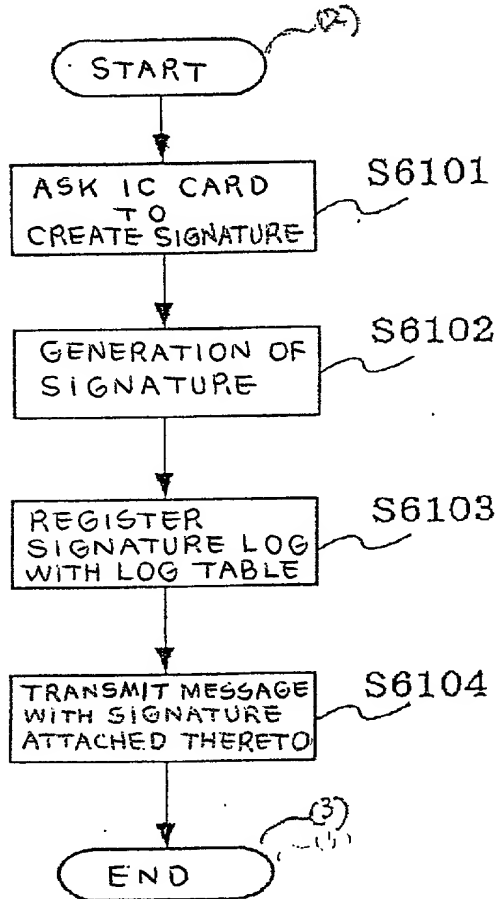
FIG. 3



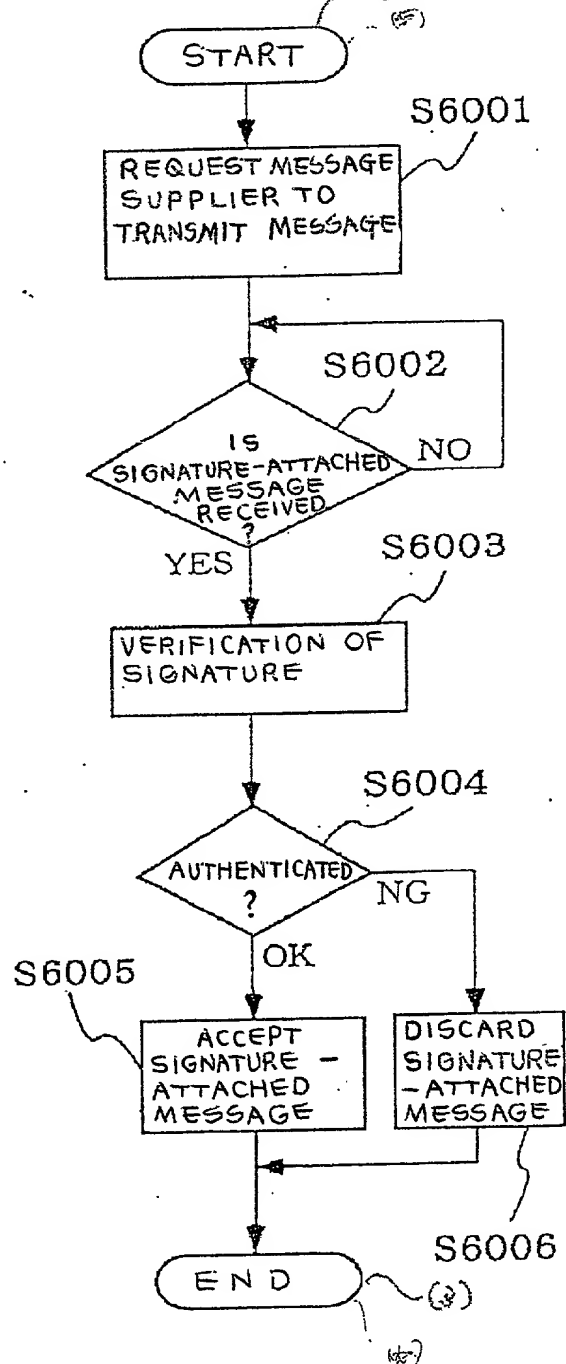
【図 4】

FIG. 4

DIGITAL SIGNER  
SIDE APPARATUS 1 (1)



PURCHASER  
SIDE APPARATUS 3 (4)  
(5)

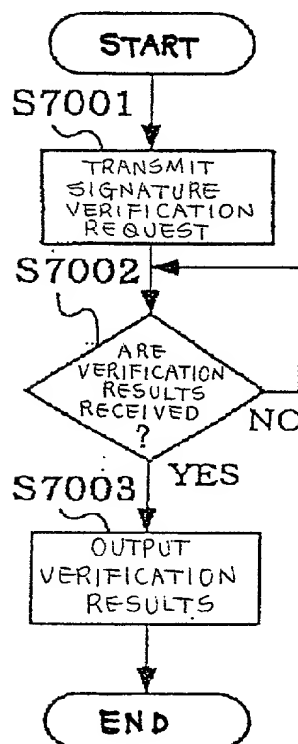




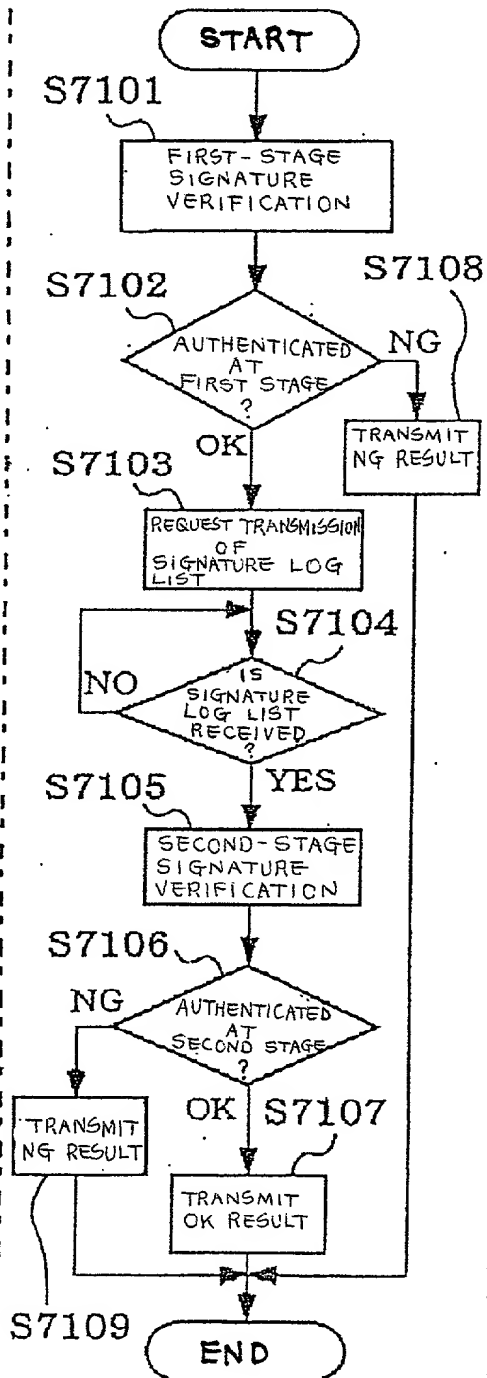
【図 5】

FIG. 5

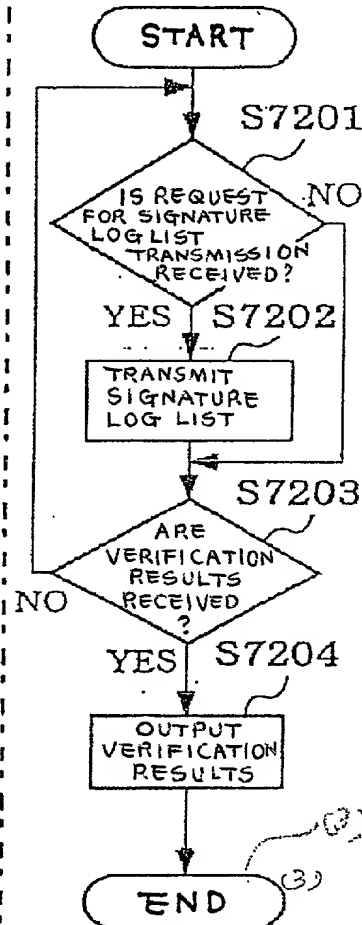
PURCHASER SIDE  
APPARATUS 3



DIGITAL SIGNATURE  
VERIFIER SIDE APPARATUS 5

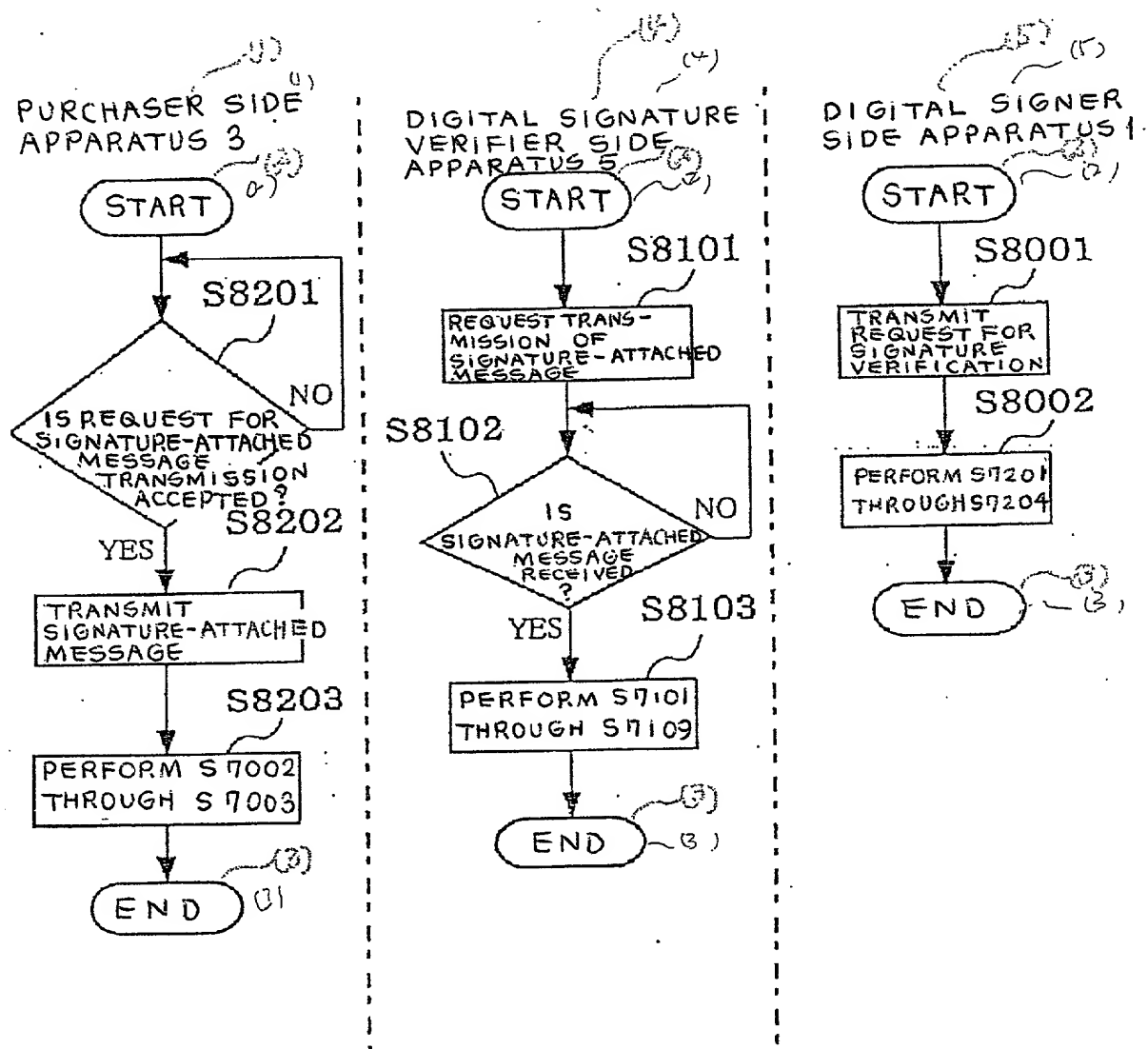


DIGITAL SIGNER SIDE  
APPARATUS 1



【図 6】

FIG. 6



【図 7】

FIG. 7

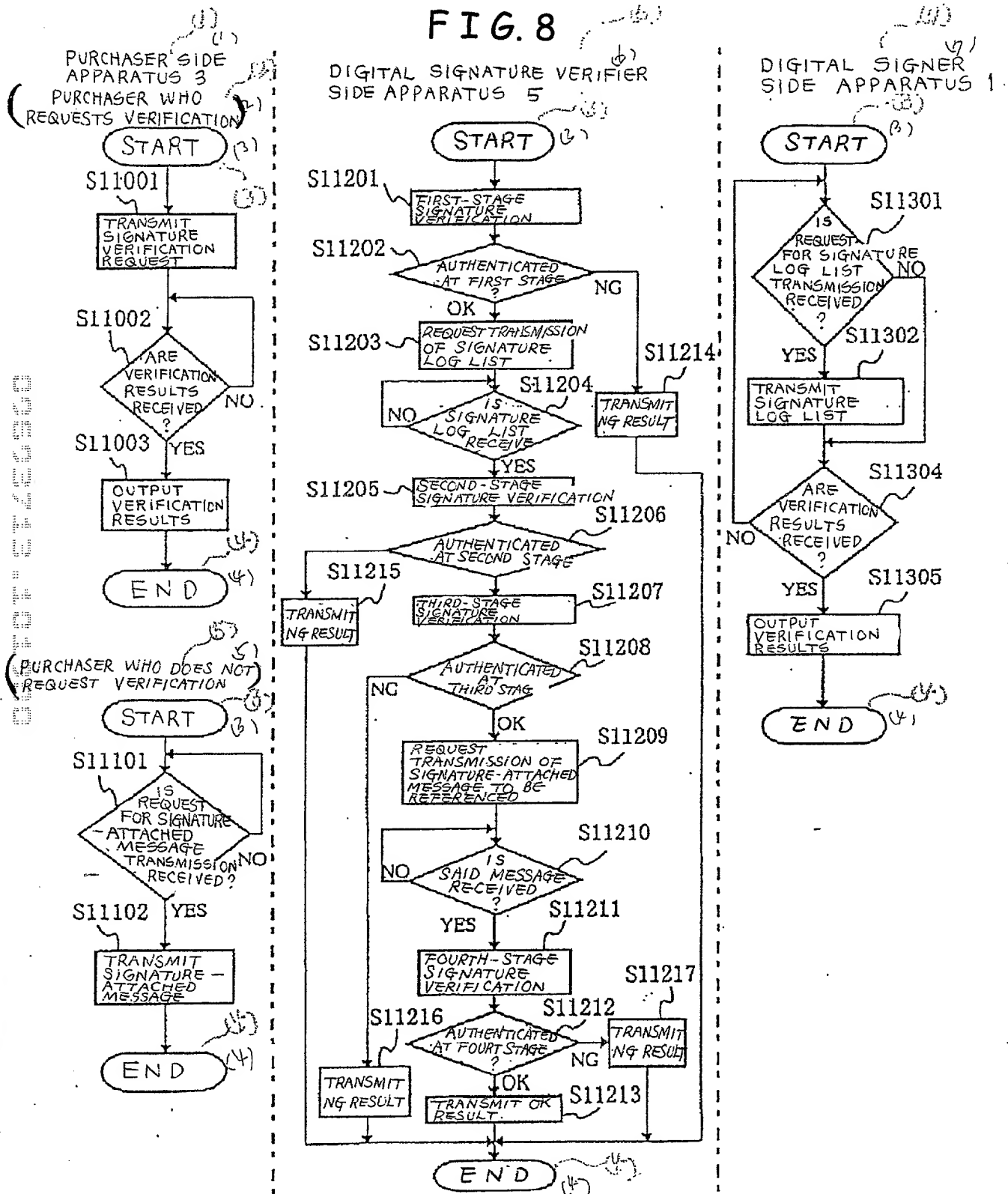
SIGNATURE LOG TABLE 2234

2235

(1) PREVIOUS DATA $P_{N-1}$ ( $h(M_{N-1}), \text{Sign}_{N-1}$ )	(2) HASH VALUE $h(M_N)$ OF MESSAGE $M_N$	(3) SIGNATURE $\text{Sign}_N$ TO (PREVIOUS DATA $P_{N-1}$ , MESSAGE $M_N$ )	(4) PURCHASER NAME
(5) PREVIOUS DATA $P_{N-2}$ ( $h(M_{N-2}), \text{Sign}_{N-2}$ )	(6) HASH VALUE $h(M_{N-1})$ OF MESSAGE $M_{N-1}$	(7) SIGNATURE $\text{Sign}_{N-1}$ TO (PREVIOUS DATA $P_{N-2}$ , MESSAGE $M_{N-1}$ )	(8) PURCHASER NAME
(9) PREVIOUS DATA $P_1$ ( $h(M_1), \text{Sign}_1$ )	(10) HASH VALUE $h(M_2)$ OF MESSAGE $M_2$	(11) SIGNATURE $\text{Sign}_2$ TO (PREVIOUS DATA $P_1$ , MESSAGE $M_2$ )	(12) PURCHASER NAME
(13) INITIAL VALUE IV	(14) HASH VALUE $h(M_1)$ OF MESSAGE $M_1$	(15) SIGNATURE $\text{Sign}_1$ TO (INITIAL VALUE IV, MESSAGE $M_1$ )	(16) PURCHASER NAME

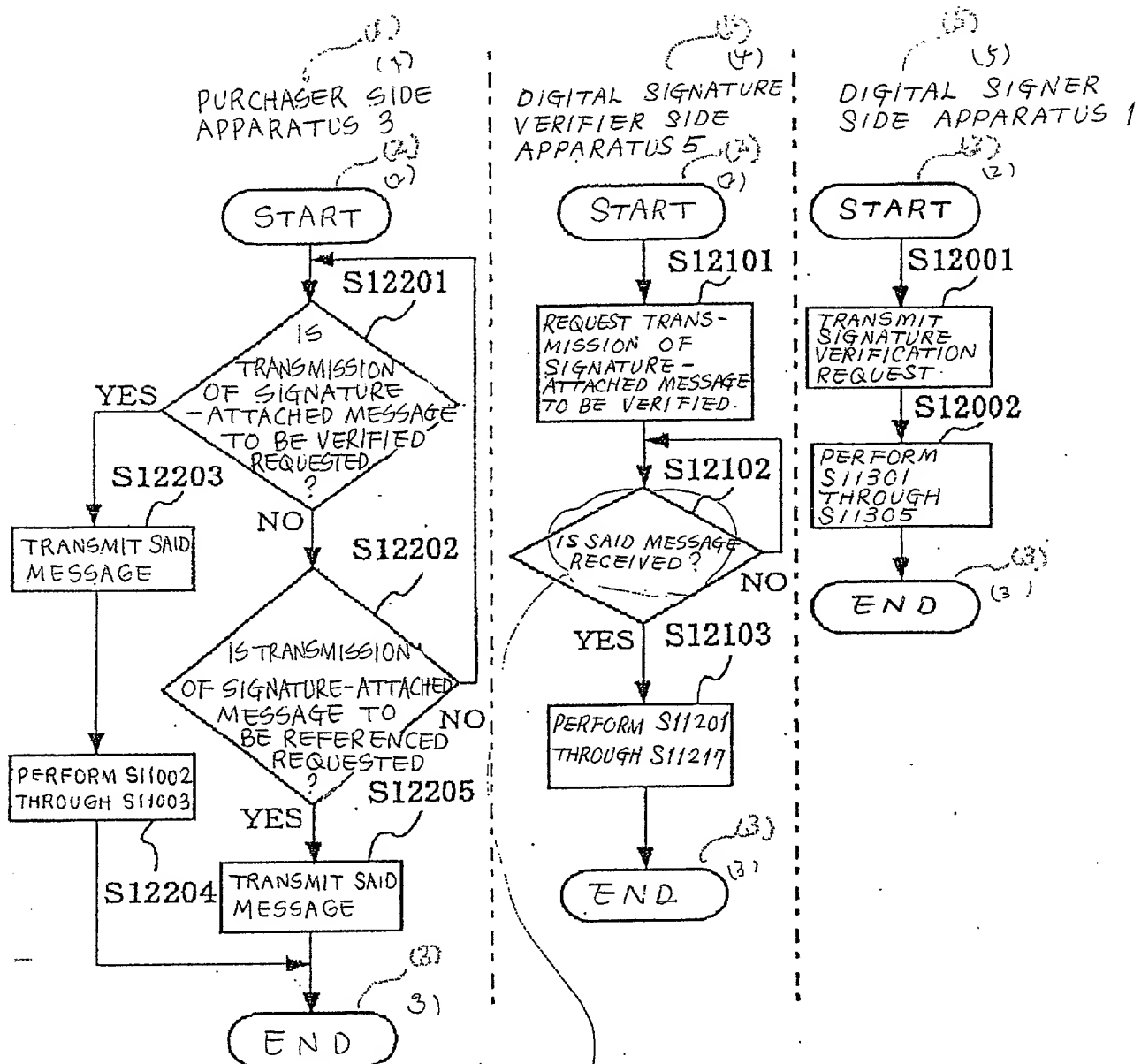
[ 図 8 ]

FIG. 8



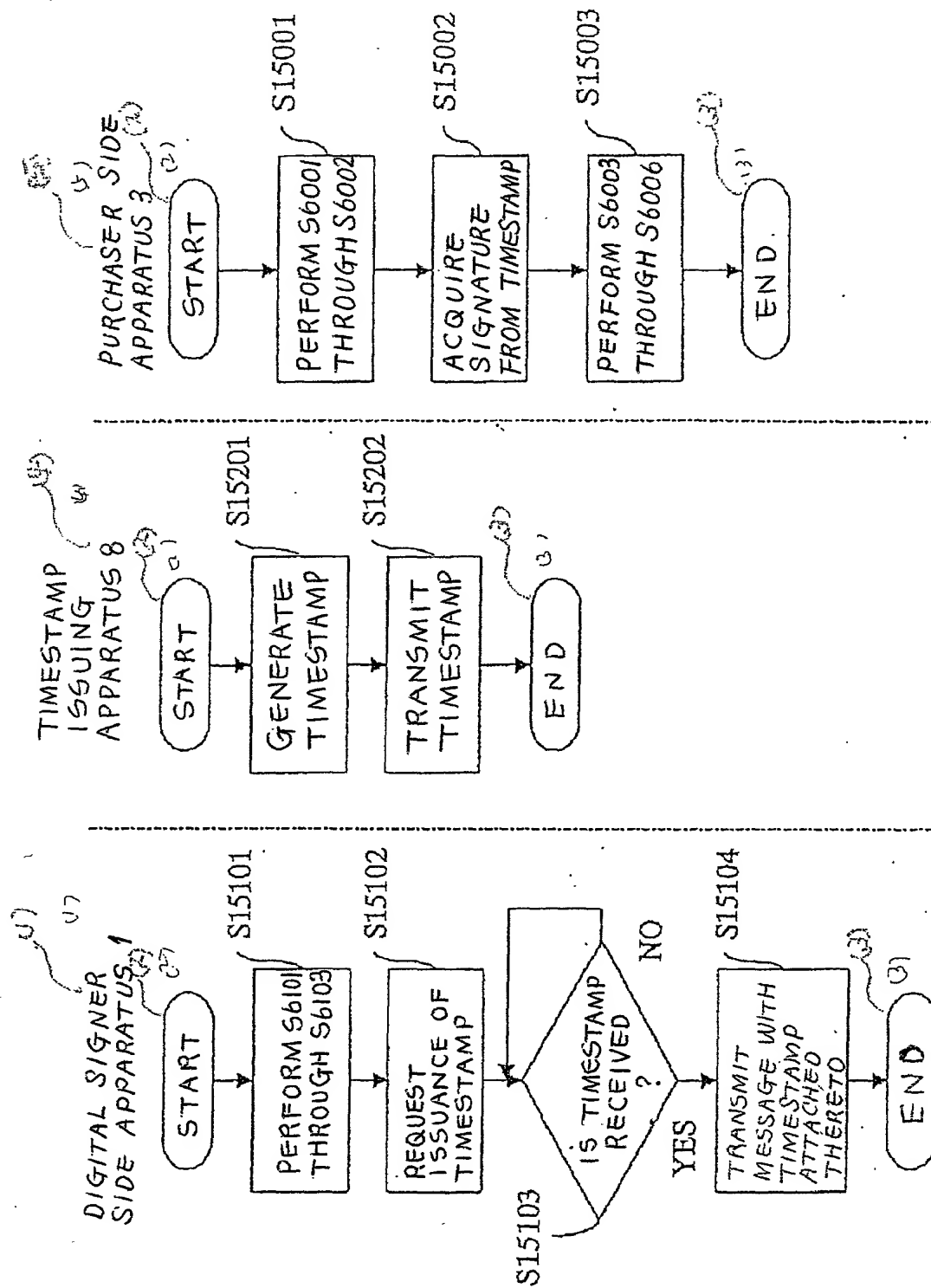
【図 9】

FIG. 9



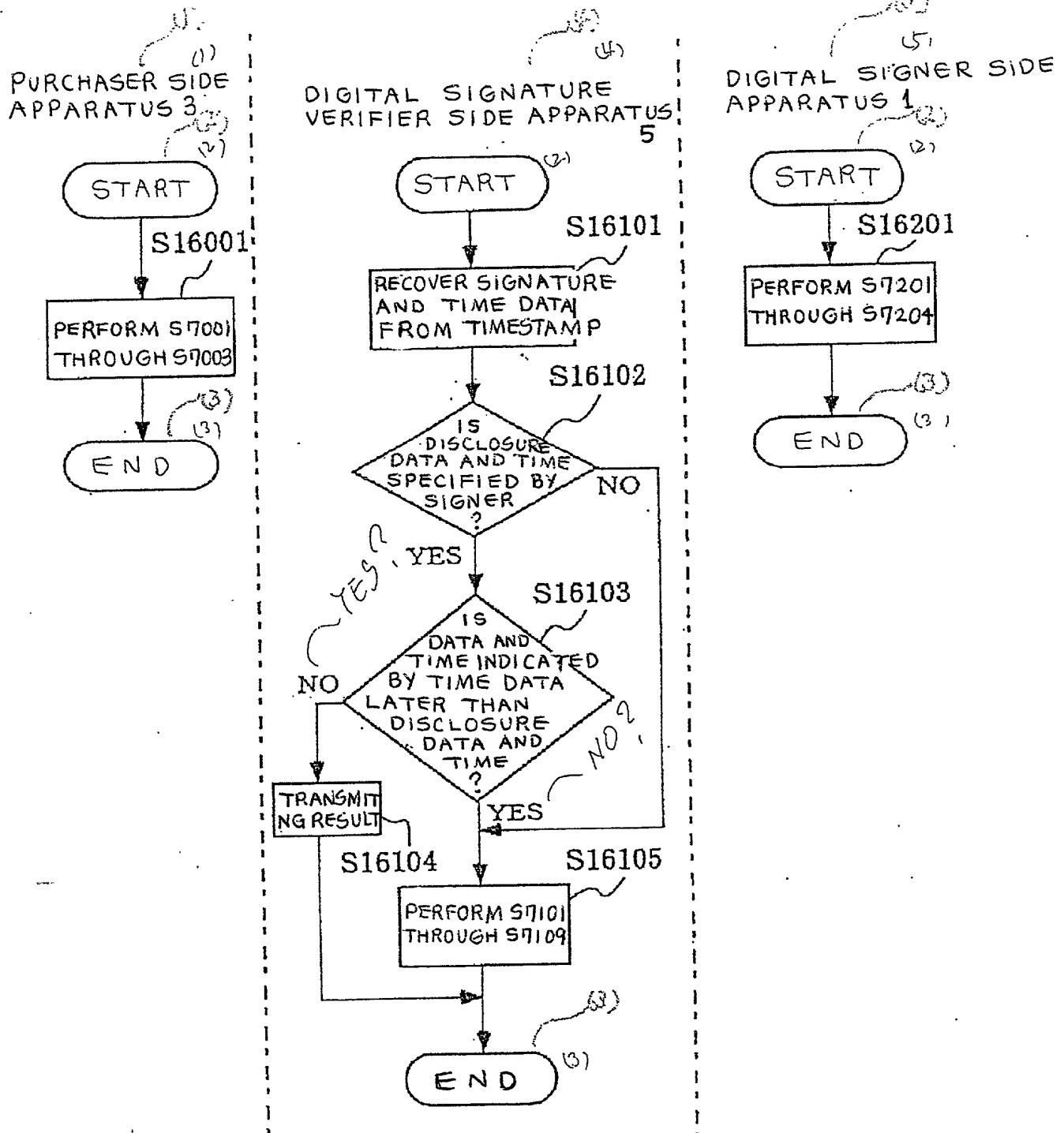
【図 10】

FIG. 10



【図 11】

FIG. 11



[ 図 1 2 ]

FIG. 12

2235

SIGNATURE LOG TABLE 2234

1) (1) HASH VALUE OF MESSAGE N	2) (2) SIGNATURE TO MESSAGE N	3) (3) PURCHASER NAME	4) (4) TIMESTAMP
5) (5) HASH VALUE OF MESSAGE N-1	6) (6) SIGNATURE TO MESSAGE N-1	7) (7) PURCHASER NAME	17) (7) NO ENTRY
⋮			
8) (8) HASH VALUE OF MESSAGE N-m	9) (9) SIGNATURE TO MESSAGE N-m	10) (9) PURCHASER NAME	11) (9) TIMESTAMP
12) (10) HASH VALUE OF MESSAGE N-m-1	13) (11) SIGNATURE TO MESSAGE N-m-1	14) (10) PURCHASER NAME	15) (10) NO ENTRY
⋮			
121) (12) HASH VALUE OF MESSAGE 2	122) (13) SIGNATURE TO MESSAGE 2	123) (12) PURCHASER NAME	124) (12) NO ENTRY
141) (14) HASH VALUE OF MESSAGE 1	142) (15) SIGNATURE TO MESSAGE 1	143) (13) PURCHASER NAME	144) (13) TIMESTAMP



## Declaration and Power of Attorney For Patent Application

## 特許出願宣言書及び委任状

## Japanese Language Declaration

## 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Digital signing method

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

☐ \_\_月\_\_日に提出され、米国出願番号または特許協定条約国際出願番号を\_\_\_\_とし、  
(該当する場合) \_\_\_\_\_に訂正されました。

☐ was filed on  
as United States Application Number or  
PCT International Application Number  
\_\_\_\_\_ and was amended on  
\_\_\_\_\_ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

# Japanese Language Declaration (日本語宣言書)

私は、米国法典第35編119条(a)-(d)項又は365条(b)項に基づき下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約365(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示している。

## Prior Foreign Application(s)

外国での先行出願

11-301216	Japan
(Number)	(Country)
(番号)	(国名)
2000-081712	Japan
(Number)	(Country)
(番号)	(国名)

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Not Claimed

優先権主張なし

22/October/1999	<input type="checkbox"/>
(Day/Month/Year Filed)	
(出願年月日)	
17/March/2000	<input type="checkbox"/>
(Day/Month/Year Filed)	
(出願年月日)	

私は、第35編米国法典119条(e)項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.)	(Filing Date)
(出願番号)	(出願日)

私は、下記の米国法典第35編120条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条(c)に基づき権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Application No.)	(Filing Date)
(出願番号)	(出願日)

(Status: Patented, Pending, Abandoned)
(現況: 特許許可済、係属中、放棄済)

(Application No.)	(Filing Date)
(出願番号)	(出願日)

(Status: Patented, Pending, Abandoned)
(現況: 特許許可済、係属中、放棄済)

私は、私自身の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じることに基き、かつ表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の表明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

### Japanese Language Declaration (日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁護士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

Robert C. Colwell, Reg. No. 27,431; William L. Shaffer, Reg. No. 37,234; Paul A. Durdik, Reg. No. 37,819; Kim Kanzaki, Reg. No. 37,652 and George B.F. Yee, Reg. No. 37,478

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国籍	Citizenship Japan	
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	

(第二以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for second and subsequent joint inventors.)

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

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第二共同発明者の署名 日付	Second inventor's signature Date <i>Ryoichi Sasaki</i> 4/8/2000
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第五共同発明者	Full name of fifth joint inventor, if any Toshiyuki MORITSU
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国籍	Citizenship Japan
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(第六以降の共同発明者についても同様に記載し、署名をすること)  
(Supply similar information and signature for sixth and subsequent joint inventors.)

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第六共同発明者	Full name of sixth joint inventor, if any Mizuhiro SAKAI	
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住所	Residence Same as post office address	
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第八共同発明者	Full name of eighth joint inventor, if any Tsutomu MATSUMOTO	
第八共同発明者の署名	日付	Eighth inventor's signature Date <i>Tsutomu Matsumoto</i> 7/9/2000
住所	Residence Same as post office address	
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第九共同発明者	Full name of ninth joint inventor, if any	
第九共同発明者の署名	日付	Ninth inventor's signature Date
住所	Residence	
国籍	Citizenship	
私書箱	Post Office Address	

(第十以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for tenth and subsequent joint inventors.)